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Storage Quality of the Principal American Varieties of Onions

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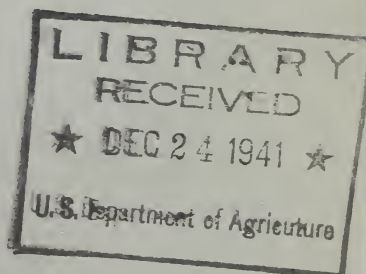
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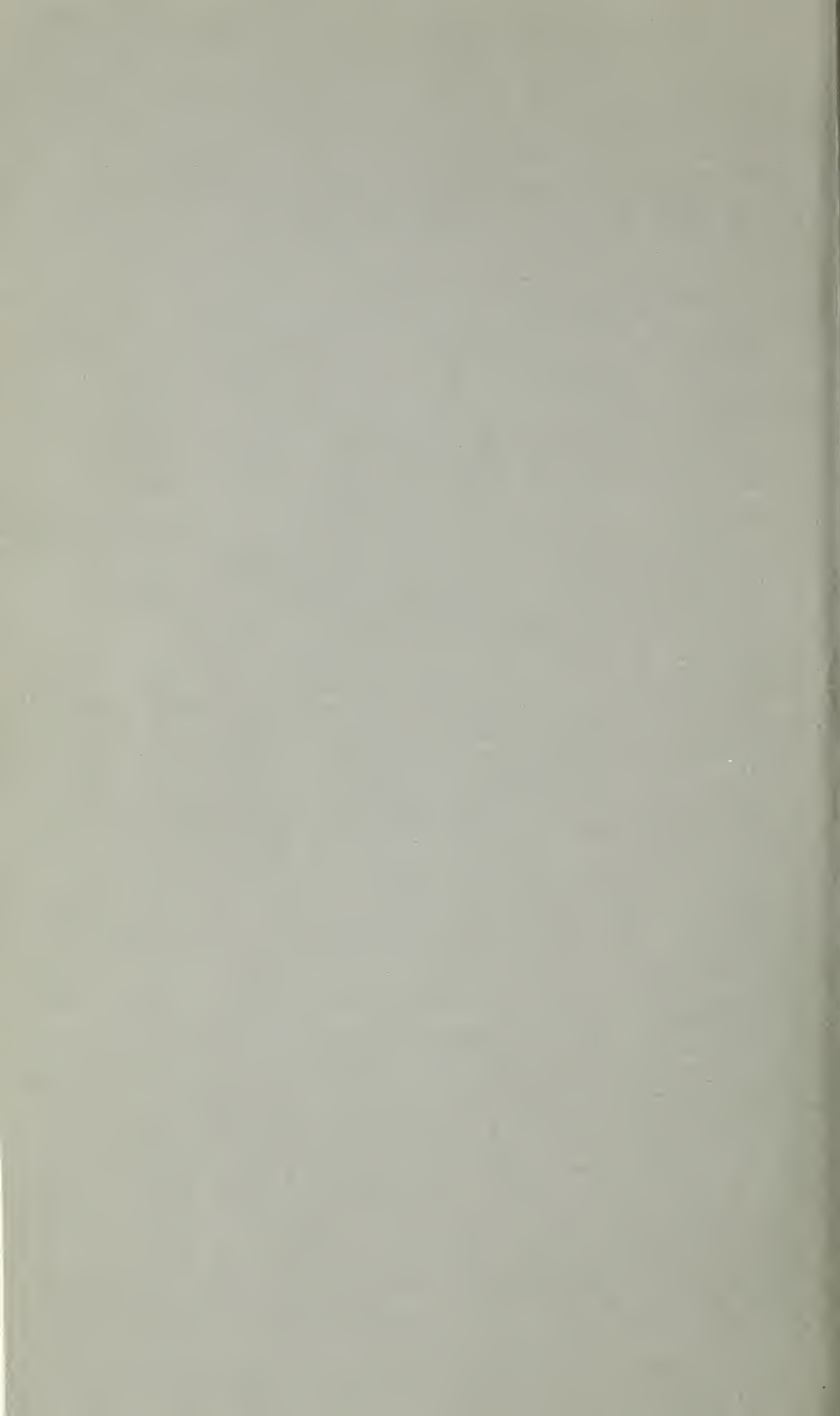
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Storage Quality of the Principal American Varieties of Onions¹

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INTRODUCTION

Because storage quality is one of the important commercial characteristics of the onion it was included in the list of characters studied in the United States Department of Agriculture Type Book project covering the principal American varieties of onions and conducted cooperatively during 1933 and 1934 by the United States Department

¹ Report of cooperative investigation by the Bureau of Plant Industry and the Agricultural Experiment Stations of California, Ohio, and Texas, and the Massachusetts State College.

² The names of the joint authors are listed according to the alphabetical order of the names of the cooperating institutions as a matter of convenience. Except for matters of an editorial nature, the various sections of the manuscript have been prepared by the above-mentioned members of each institution.

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of Agriculture and the State Experiment Stations of California, Ohio, and Texas, and the Massachusetts State College.

The same strains of seed were used by all collaborators during both years of the test, and the combining of the results of the individual tests in this circular makes possible a comparison of the storage quality of the crop from the same strain of seed grown and stored under different conditions as well as a comparison between different strains of the same variety and between the different varieties.

MATERIALS

Seed was furnished for the type book studies by a number of American onion seed producers in quantity sufficient for both years of the trials. In order to avoid bias the source of the seed was not divulged; strains were identified by numbers only. After the first year's trial, only the two strains of the greatest uniformity and trueness to type were planted.

Cultural details, storage conditions, and results are presented separately for each location.

ARLINGTON, VA.

CULTURAL METHODS AND CONDITIONS (1933 AND 1934)

Seed was sown at the Arlington Experiment Farm, Arlington, Va., in flats in the greenhouse December 15, 1932, and December 20, 1933. The seedlings were grown slowly, at a cool temperature until they were set in the field on March 17, 1933, and April 10, 1934. Both crops were grown on a plot that had been well manured and fertilized for several years incidental to growing other vegetables. The soil was a silt loam that was perhaps a little too heavy in texture for best results with onions, but it was well drained and excellent top growth was obtained. Before planting, 1,000 pounds per acre of a 5-8-5 fertilizer was broadcast and disked in. The plants were set 3 or 4 inches apart (depending on variety) in rows 15 inches apart. When transplanted, the bases of the plants were about one-eighth of an inch in diameter, and the tops were trimmed to 6 inches in length.

In both years the weather was very favorable for good growth from transplanting time through April. From May onward, high temperatures prevailed, and in 1934 it was necessary to irrigate about July 10 and 20. Thrips infection was severe both years despite numerous sprays and dusts applied to control them.

Later maturing varieties appeared to be more seriously damaged by heat and thrips than were the earlier varieties, especially in the 1934 crop, which was transplanted rather late. The average bulb size (weight) was less in 1934 than in 1933.

The harvest dates for the respective varieties were quite similar in both years. (See tables 1 and 7.) In 1934 harvesting and curing conditions were good. The plants were pulled, placed in slatted bushel onion crates—one-third full—and the crates stacked in the field and covered with roofing paper 7 to 10 days until the bulbs were dry. The onions were then topped, cleaned, weighed, replaced

in crates, and stacked in a greenhouse head house at a low humidity and a temperature of 70° to 85° F. until samples were prepared for the storage tests.

In 1933 rains and high humidity at harvest and curing time resulted in poor curing and considerable rotting of the bulbs in the crates. It was necessary to spread the onions on a vacant greenhouse floor to dry them 3 to 5 days, thus stopping the serious rotting. This sudden artificial drying, in contrast to normal maturing and curing, resulted in the necks of the bulbs being thicker than normal and not shrunken to a good closure after the tops were removed. After drying, topping and cleaning, and weighing, the bulbs were replaced in crates and stored in a greenhouse head house August 5 to September 5. The losses from rot during this period were heavy (see table 4), necessitating combining certain strains of some varieties to make up the storage test lots. (See table 1.)

Only typical sound hard bulbs with one or more intact dry outer scales, free from discoloration, and of 1¼-inch diameter or larger were used in the storage tests of each variety.

1933 COLD-STORAGE CONDITIONS AND RECORDS ⁴

The selected bulbs (number and average weight are shown in table 1) were stored in slatted bushel onion crates one-half to nine-tenths full, stacked along one side of the cold storage room shoulder high, with the stacks as close together as possible.

From September 5, 1933, to January 6, 1934, the onions were stored at 32° F. \pm 1° and a relative humidity of 68 to 70 percent, and from January 6 to June 12, 1934, at 40° \pm 1° and a relative humidity of 55 to 60 percent.

On each inspection date the bulbs were removed from storage, weighed immediately on scales accurate to one-tenth pound, and sorted. Bulbs with roots one-eighth inch or longer were first sorted out and counted but not discarded, as roots are easily rubbed or broken off in handling and do not seriously affect the market grade. Bulbs with visible sprouts, or rotting, and those so soft or shriveled as to be unmarketable were discarded. The number of bulbs in each class and the total weight of all discards were recorded. Bulbs that had both sprouted and rotted were recorded as sprouted.

1933 COLD-STORAGE RESULTS

The varieties are arranged in the tables in groups with the poorest storage varieties at the top and the best at the bottom of each group, based on the percentage of sound bulbs at the March 6, 1934, inspection. (Strains of the Southport and Ebenezer varieties have been kept together as well as varieties within the Spanish and storage types.) Storage is seldom profitable much beyond March 6 because of the heavy losses in storage and the competition with new crop Bermuda onions from Texas.

⁴ Cold-storage facilities and valuable advice were supplied through the cooperation of the Storage and Transportation Section of the Division of Fruit and Vegetable Crops and Diseases.

The data in table 1 indicate marked differences in the ability of the different varieties and strains to remain marketable in storage. California Early Red, Yellow Bermuda, and Crystal Wax were the poorest keepers and decreased markedly in percentage of sound bulbs after January 6. Mountain Danvers, Early Yellow Globe, and the Sweet Spanish group of Sweet Spanish, White Sweet Spanish, and Prizetaker held up in storage fairly well until about February 6. There were no significant differences at any time between the two strains of Sweet Spanish, but strain 2 of Prizetaker seemed to be slightly better than strain 1, and White Sweet Spanish was superior to the strains of Prizetaker and Sweet Spanish toward the latter part of the storage period. The remainder of the list of varieties in table 1 retained about 75 percent of their bulbs in usable condition until after April 6. Ebenezer and Yellow Globe Danvers held up a little longer than the other varieties in this group. The small differences between the two strains of Ebenezer and between the Southport Globes are probably not significant.

The reasons for the total loss of bulbs on successive dates shown in table 1 are given in detail in tables 3 to 5.

TABLE 1.—Percentage of the original weight of onion bulbs harvested at different dates and stored Sept. 5, 1933, that remained sound in cold storage at Arlington, Va., at each inspection, 1933-34

Variety	Strain No.	Original weight of 100 bulbs	Date harvested	Sound bulbs remaining on inspection dates shown									
				Oct. 4	Nov. 6	Dec. 6	Jan. 6	Feb. 6	Mar. 6	Apr. 6	May 7	June 12	
		<i>Lb.</i>		<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	
California Early Red	1	21.3	July 11	97.7	94.5	90.6	87.5	55.1	1.0	0.0	0.0	0.0	
Yellow Bermuda	3, 4	16.8	July 6	97.9	94.3	90.8	88.1	70.5	2.1	1.2	.9	0	
Crystal Wax	1-4	19.8	do	96.6	91.6	87.5	83.4	71.6	2.4	2.0	1.0	0	
Sweet Spanish	5	29.6	July 27	99.0	97.4	95.6	93.8	81.7	61.2	42.5	17.9	12.5	
Do	4	32.9	do	98.9	97.0	95.6	94.7	83.8	62.5	43.7	25.1	17.3	
Prizetaker	1	24.4	do	97.9	94.7	91.4	90.6	82.8	63.1	41.8	22.9	10.2	
Do	2	25.5	do	99.2	96.9	95.3	94.1	89.8	76.5	51.4	28.6	19.6	
White Sweet Spanish	1	26.2	July 25	98.7	96.6	94.9	93.0	89.2	74.7	58.4	44.2	33.5	
Mountain Danvers	1	19.5	July 10	98.6	96.7	94.6	93.8	86.2	59.5	39.0	20.3	8.2	
Early Yellow Globe	1	16.7	do	98.8	95.6	93.2	92.8	87.2	74.1	57.4	40.2	26.7	
Red Wethersfield	3, 4	16.2	July 20	98.8	96.6	94.1	93.8	89.5	79.3	69.7	51.1	37.2	
Yellow Strasburg	2	17.5	July 12	97.6	94.4	91.6	91.2	87.6	83.5	76.3	68.3	49.0	
Ohio Yellow Globe	1	18.6	July 11	98.7	96.8	95.7	95.2	91.4	84.1	72.0	63.2	43.0	
Southport Yellow Globe	3	17.3	July 12	98.2	96.4	94.7	94.7	90.7	81.8	73.8	63.6	55.6	
Southport Red Globe	2, 3	15.3	do	99.0	97.7	95.1	94.8	92.2	87.9	76.5	68.9	54.9	
Southport White Globe	1, 3	17.7	do	98.9	96.6	94.6	93.2	91.5	88.1	81.6	63.7	51.3	
Ebenezer	4	15.5	do	97.7	95.8	93.9	93.5	91.6	87.1	82.2	75.7	64.7	
Do	6	17.3	do	98.8	97.4	96.0	95.7	92.2	89.3	82.7	73.4	62.4	
Australian Brown	2, 3	16.9	July 25	98.8	97.6	96.0	95.8	93.5	89.3	79.5	70.3	56.7	
White Portugal	2, 3	16.0	July 12	98.7	96.9	94.4	93.7	91.6	89.4	81.6	53.4	50.0	
Yellow Danvers Flat	1	19.8	do	100.0	97.3	95.9	95.3	92.6	89.5	81.8	68.2	52.0	
Yellow Globe Danvers	3	16.9	July 11	99.4	97.6	96.4	96.2	94.4	92.6	87.3	76.9	62.7	

Although bulbs with new roots were not discarded, the appearance of roots is negatively correlated with good storage quality, as shown in table 2. Roots in appreciable number appeared on the poorer storage varieties in 3 to 4 months, whereas the better storage varieties required about 5 months. It was also observed that, in general, the

varieties showing the earliest appearance of roots were those with the earliest top growth or sprouts, although top growth was as much as 1 to 3 months later in appearance. (Compare tables 2 and 3.)

It is shown in table 3 that California Early Red, Yellow Bermuda, and Crystal Wax were the first varieties to produce an appreciable number of sprouted bulbs. Mountain Danvers, Early Yellow Globe, and Red Wethersfield produced slightly more early "sprouters" than the Spanish group of varieties and many more than the ordinary winter storage varieties (the remainder of the list). White Portugal and Yellow Globe Danvers were the slowest to produce sprouts and had the lowest total percentage of sprouts.

Although the bulbs were very carefully selected at an interval long enough after harvest for most of the initial rot infections to have developed and decayed bulbs to have been discarded, a small number of bulbs were attacked by various rots during the storage period as shown in table 4. Most of the rots developed in the first month after the change from the 32° to the 40° F. storage rooms (January 6 to February 6). The majority of the loss was from neck rot although there was a small percentage of side and basal rot. It is noteworthy that some of the varieties with the lowest precold-storage losses also had no rots develop during the long storage period.

TABLE 2.—Percentage of onion bulbs stored Sept. 5, 1933, that remained in cold storage at Arlington, Va., which showed new roots at each inspection, 1933-34

Variety	Strain No.	Bulbs with new roots on inspection dates shown					
		Dec. 6	Jan. 6	Feb. 6	Mar. 6	Apr. 6	May 7
		Percent	Percent	Percent	Percent	Percent	Percent
California Early Red.....	1	1.1	32.2	55.9	100.0	-----	-----
Yellow Bermuda.....	3,4	3.5	32.5	64.3	94.7	-----	-----
Crystal Wax.....	1-4	15.1	57.6	57.0	93.1	-----	-----
Sweet Spanish.....	5	.6	0	41.1	72.5	44.1	12.5
Do.....	4	0	6.3	41.1	72.1	47.8	33.8
Prizetaker.....	1	1.0	4.0	65.7	80.8	50.7	31.5
Do.....	2	0	7.0	67.7	74.7	56.4	41.0
White Sweet Spanish.....	1	.6	2.8	32.4	74.6	62.1	25.4
Mountain Danvers.....	1	0	0	30.1	74.2	22.6	4.1
Early Yellow Globe.....	1	0	0	18.0	54.5	15.9	33.3
Red Wethersfield.....	3,4	0	0	11.6	30.0	35.0	10.4
Yellow Strasburg.....	2	0	0	3.0	14.6	4.8	6.9
Ohio Yellow Globe.....	1	0	0	7.5	37.4	12.1	25.1
Southport Yellow Globe.....	3	0	0	3.1	7.9	1.8	2.8
Southport Red Globe.....	2,3	0	0	2.5	14.4	22.2	5.4
Southport White Globe.....	1,3	0	0	8.7	39.8	5.7	21.9
Ebenezer.....	4	0	0	4.1	21.9	2.6	.5
Do.....	6	0	0	6.5	34.5	8.7	25.7
Australian Brown.....	2,3	0	0	9.5	38.7	14.5	17.4
White Portugal.....	2,3	0	0	3.6	24.2	1.0	-----
Yellow Danvers Flat.....	1	0	0	8.5	34.2	12.1	9.6
Yellow Globe Danvers.....	3	0	0	4.0	18.0	31.2	9.2

TABLE 3.—Percentage of the original number of onion bulbs stored Sept. 3, 1933, that was discarded at each inspection because of sprouting or because of softening or shriveling in cold storage at Arlington, Va., 1933-34

ONIONS DISCARDED BECAUSE OF SPROUTING

Variety	Strain No.	Bulbs discarded on inspection dates shown					
		Feb. 6 ¹	Mar. 6	Apr. 6	May 7	June 12	Total
		Percent	Percent	Percent	Percent	Percent	Percent
California Early Red.....	1	26.1	36.1	0.0			62.2
Yellow Bermuda.....	3, 4	11.0	46.0	0	0.0	0.0	57.5
Crystal Wax.....	1-4	6.5	42.0	0	0	0	49.5
Sweet Spanish.....	5	.6	1.2	6.5	8.2	4.7	21.2
Do.....	4	.6	5.0	5.6	8.1	7.5	26.8
Prizetaker.....	1	1.0	8.0	3.0	10.0	9.0	31.0
Do.....	2	2.0	6.0	10.0	9.0	9.0	36.0
White Sweet Spanish.....	1	0	6.7	5.0	6.1	11.7	29.5
Mountain Danvers.....	1	3.5	18.0	18.5	14.5	15.0	69.5
Early Yellow Globe.....	1	2.7	8.7	10.7	10.0	11.3	43.4
Red Wethersfield.....	3, 4	2.5	6.0	2.0	10.0	12.5	33.0
Yellow Strasburg.....	2	.5	1.0	3.5	4.5	18.5	28.5
Ohio Yellow Globe.....	1	1.5	3.0	6.0	3.5	13.0	27.0
Southport Yellow Globe.....	3	.8	6.1	3.1	6.1	5.4	22.3
Southport Red Globe.....	2, 3	.5	.5	2.5	2.0	10.5	16.5
Southport White Globe.....	1, 3	0	1.5	4.0	6.0	12.0	23.5
Ebenezer.....	4	.5	2.5	1.5	2.5	8.0	15.0
Do.....	6	1.5	1.0	2.5	5.0	8.5	18.5
Australian Brown.....	2, 3	.5	2.0	3.5	4.5	10.5	21.0
White Portugal.....	2, 3	0	0	1.5	3.5	2.5	7.5
Yellow Danvers Flat.....	1	.5	.5	3.0	4.5	13.5	22.0
Yellow Globe Danvers.....	3	0	0	0	1.0	9.0	10.0

ONIONS DISCARDED BECAUSE OF SOFTENING OR SHRIVELING²

California Early Red.....	1		30.5	2.2			32.7
Yellow Bermuda.....	3, 4		32.5	2.0	0.0	1.5	36.0
Crystal Wax.....	1-4		42.0	0	2.0	1.5	45.5
Sweet Spanish.....	5		12.9	11.7	19.4	2.9	46.9
Do.....	4		11.8	16.8	10.0	0	38.6
Prizetaker.....	1		11.0	18.0	14.0	6.0	49.0
Do.....	2		5.0	14.0	14.0	1.0	34.0
White Sweet Spanish.....	1		4.4	11.6	8.9	0	24.9
Mountain Danvers.....	1		8.0	1.5	7.5	.5	17.5
Early Yellow Globe.....	1		4.0	3.3	8.0	3.3	18.6
Red Wethersfield.....	3, 4		2.0	5.0	9.0	4.0	20.0
Yellow Strasburg.....	2		0	1.0	3.0	2.5	6.5
Ohio Yellow Globe.....	1		2.5	3.5	4.0	9.0	19.0
Southport Yellow Globe.....	3		2.3	2.3	4.6	.8	10.0
Southport Red Globe.....	2, 3		2.0	8.0	3.5	3.0	16.5
Southport White Globe.....	1, 3		0	.5	6.0	0	6.5
Ebenezer.....	4		.5	1.0	1.5	2.0	5.0
Do.....	6		0	1.5	4.0	2.0	7.5
Australian Brown.....	2, 3		.5	4.0	2.5	3.0	10.0
White Portugal.....	2, 3		1.0	3.0	4.0	.5	8.5
Yellow Danvers Flat.....	1		0	2.5	6.0	4.0	12.5
Yellow Globe Danvers.....	3		.5	2.0	8.0	4.0	14.5

¹ Oct. 4, Southport Yellow Globe 0.8 percent; Nov. 6, Yellow Strasburg 0.5 percent; Jan. 6, Yellow Bermuda 0.5 percent, Crystal Wax 1.0 percent, Southport Red Globe 0.5 percent.

² None discarded prior to Mar. 6, 1934.

TABLE 4.—Percentage of the original number of onion bulbs stored Sept. 5, 1933, that was discarded on or between inspection dates because of decay or rotting in cold storage at Arlington, Va., 1933-34, and percentage of rots that developed between harvest and the start of cold storage

Variety	Strain No.	Rots (harvest to storage)	Bulbs discarded on or between inspection dates shown				
			Sept. 5 to Jan. 6	Feb. 6	Mar. 6	Apr. 6 to June 12	Total
		Percent	Percent	Percent	Percent	Percent	Percent
California Early Red.....	1	8.1	1.7	3.3	0.0	0.0	5.0
Yellow Bermuda.....	3,4	21.0	0	3.5	.5	0	4.0
Crystal Wax.....	1-4	34.7	2.5	2.5	.5	0	5.5
Sweet Spanish.....	5	18.7	1.2	8.2	5.3	.6	15.3
Do.....	4	20.3	1.2	6.2	4.4	.6	12.4
Prizetaker.....	1	16.2	1.0	4.0	0	0	5.0
Do.....	2	30.5	1.0	0	1.0	3.0	5.0
White Sweet Spanish.....	1	17.4	.6	1.1	.6	.6	2.9
Mountain Danvers.....	1	14.5	.5	1.0	.5	0	2.0
Early Yellow Globe.....	1	25.1	0	.7	0	.7	1.4
Red Wethersfield.....	3,4	41.6	.5	.5	0	.5	1.5
Yellow Strasburg.....	2	9.1	0	0	0	0	0
Ohio Yellow Globe.....	1	34.3	.5	.5	1.0	0	2.0
Southport Yellow Globe.....	3	40.3	0	1.5	0	0	1.5
Southport Red Globe.....	2,3	34.7	1.0	.5	.5	0	2.0
Southport White Globe.....	1,3	24.2	2.0	0	.5	0	2.5
Ebenezer.....	4	18.6	1.5	0	0	0	1.5
Do.....	6	12.1	0	0	0	0	0
Australian Brown.....	2,3	25.5	0	0	.5	0	.5
White Portugal.....	2,3	16.4	2.5	.5	0	0	3.0
Yellow Danvers Flat.....	1	11.4	0	0	0	2.0	2.0
Yellow Globe Danvers.....	3	19.6	0	0	0	0	0

In January it was apparent that some bulbs were softening or shriveling. Beginning with March 6 unsalable bulbs of this class were discarded, and probably some should have been in February. The results (see table 3) show a high percentage loss on March 6 for California Early Red, Yellow Bermuda, and Crystal Wax. There was more loss from shriveling and softening in the Sweet Spanish group than in the other common storage varieties.

Table 5 shows the total percentage loss in weight due to bulbs discarded because of rotting, softening or shriveling, or new top growth, and supplements tables 3 and 4, which showed percentage loss based on number of bulbs discarded for the different reasons. The losses were very small during the first 4 months in the 32° F. storage room, but there was an appreciable increase in most varieties after a month in the 40° room. The large percentage discarded on May 7 for Southport White Globe and White Portugal was due mainly to a large number of bulbs that had developed sufficient smudge (*Colletotrichum circinans* (Berk.) Vogl.) to make them unsalable.

The loss in weight of sound and unsound bulbs in the interval between inspection dates also contributes to the total loss in weight. Variations in the losses for the first 3 months (table 6) are probably not significant, and the cause for the decrease in percentage loss of most varieties between December 6 and January 6 is not known. The heavier loss for the January 6 to February 6 period followed the change in storage temperature from 32° to 40° F. In general, the monthly loss increased throughout the storage period and correlates very closely with the storage quality of the different varieties.

TABLE 5.—Percentage of the original weight of onion bulbs stored Sept. 5, 1933, that was discarded because of sprouting, rotting, or softening or shriveling in cold storage at Arlington, Va., at each inspection, 1933-34

[See tables 3 and 4]

Variety	Strain No.	Bulbs discarded on inspection date shown								Total
		Oct. 4 and Nov. 6	Dec. 6 and Jan. 6	Feb. 6	Mar. 6	Apr. 6	May 7	June 12		
		Percent	Percent	Percent	Percent	Percent	Percent	Percent		
California Early Red	1	0.0	0.8	28.2	51.7	1.0			81.7	
Yellow Bermuda	3,4	0	.3	13.1	64.3	0	0.9	0.9	79.5	
Crystal Wax	1-4	.6	1.3	6.8	64.6	0	1.0	1.0	75.3	
Sweet Spanish	5	0	.6	8.9	18.1	16.1	22.9	4.5	71.1	
Do	4	.4	.2	7.4	19.0	16.2	16.7	6.5	66.4	
Prizetaker	1	0	.8	4.5	16.0	17.6	16.8	11.1	66.8	
Do	2	0	.4	1.6	10.2	21.2	20.4	7.1	60.9	
White Sweet Spanish	1	0	.2	1.1	12.3	18.3	11.7	8.7	52.3	
Mountain Danvers	1	0	.3	4.6	24.1	17.2	17.7	10.8	74.7	
Early Yellow Globe	1	0	0	2.4	10.4	12.7	14.3	11.6	51.4	
Red Wethersfield	3,4	0	.3	2.2	7.7	6.2	17.0	12.1	45.5	
Yellow Strasburg	2	.4	0	.8	2.0	3.6	4.8	15.3	26.9	
Ohio Yellow Globe	1	.3	0	1.9	5.6	8.9	6.7	17.2	40.6	
Southport Yellow Globe	3	.4	0	2.2	7.1	4.9	8.0	4.9	27.5	
Southport Red Globe	2,3	0	1.0	.7	2.6	8.2	4.9	11.4	28.8	
Southport White Globe	1,3	.6	.6	0	2.0	3.4	15.3	9.9	31.8	
Ebenezer	4	.6	.3	.3	2.9	1.9	4.2	7.8	18.0	
Do	6	0	0	1.7	1.2	3.5	5.9	7.8	20.1	
Australian Brown	2,3	0	0	.9	2.4	6.5	6.5	10.4	26.7	
White Portugal	2,3	.6	1.2	.6	.6	5.0	25.9	1.9	35.8	
Yellow Danvers Flat	1	0	0	.7	.3	5.1	10.8	12.2	29.1	
Yellow Globe Danvers	3	0	0	0	.3	2.1	7.7	10.7	20.8	

TABLE 6.—Percentage loss in weight, between inspection dates, of sound and unsound onion bulbs stored Sept. 5, 1933, in cold storage at Arlington, Va., 1933-34

Variety	Strain No.	Loss in weight between inspection dates shown										Total
		Sept. 5 to Oct. 4	Oct. 4 to Nov. 6	Nov. 6 to Dec. 6	Dec. 6 to Jan. 6	Jan. 6 to Feb. 6	Feb. 6 to Mar. 6	Mar. 6 to Apr. 6	Apr. 6 to May 7	May 7 to June 12		
		Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.		
California Early Red	1	2.3	3.2	3.3	3.5	4.8	4.3	16.7	14.3	-----	32.4	
Yellow Bermuda	3,4	2.1	3.6	3.8	2.6	5.1	5.9	10.2	19.1	-----	42.4	
Crystal Wax	1-4	3.0	4.9	4.1	3.5	6.1	6.6	19.3	14.8	-----	42.3	
Sweet Spanish	5	1.0	1.6	1.6	1.5	3.4	2.9	4.2	4.2	4.4	24.8	
Do	4	1.1	1.5	1.2	1.0	3.6	2.7	4.3	4.3	5.3	25.0	
Prizetaker	1	2.0	3.3	2.6	.9	3.6	4.5	5.8	4.9	7.1	34.7	
Do	2	.8	2.4	1.6	.8	2.9	3.5	5.1	4.6	6.8	28.5	
White Sweet Spanish	1	1.3	2.2	1.5	2.0	1.6	2.4	2.6	4.4	4.3	22.3	
Mountain Danvers	1	1.3	2.1	1.9	.8	3.3	3.0	5.6	3.9	6.3	28.2	
Early Yellow Globe	1	1.2	3.2	2.5	.4	3.4	3.2	5.4	4.9	5.0	29.2	
Red Wethersfield	3,4	1.2	2.2	2.2	.3	2.3	2.8	4.3	2.2	3.6	21.1	
Yellow Strasburg	2	2.4	2.9	3.0	.4	3.1	2.3	4.3	4.2	5.9	28.5	
Ohio Yellow Globe	1	1.1	1.9	1.4	.6	2.0	1.8	3.8	3.0	4.7	20.3	
Southport Yellow Globe	3	1.3	1.8	1.8	0	1.9	2.0	3.8	3.0	4.9	20.5	
Southport Red Globe	2,3	1.0	1.3	2.0	0	2.1	1.8	3.7	3.4	3.8	19.1	
Southport White Globe	1,3	1.1	1.7	1.5	1.5	1.8	1.5	3.5	3.1	4.0	19.7	
Ebenezer	4	1.6	2.0	1.7	.3	1.7	1.8	3.3	2.8	4.3	19.5	
Do	6	1.2	1.5	1.5	.3	1.8	1.9	3.6	3.1	4.3	19.2	
Australian Brown	2,3	1.2	1.2	1.5	.6	1.5	1.9	3.7	3.4	4.6	19.6	
White Portugal	2,3	.6	1.9	1.6	.3	1.7	1.7	3.1	2.7	2.9	16.5	
Yellow Danvers Flat	1	0	2.7	1.4	.7	2.1	2.9	3.0	3.3	5.9	22.0	
Yellow Globe Danvers	3	.6	1.8	1.5	.3	1.8	1.6	3.5	2.7	4.6	18.4	

¹ Based on soft or shriveled bulbs.

1934 COLD-STORAGE CONDITIONS AND RECORDS

One hundred onions of each variety and strain selected for study were placed not over two bulbs deep in flats 4 inches deep, which were stacked in a cold-storage room at $40^{\circ} \pm 1^{\circ}$ F. on August 16, 1934, with $\frac{1}{2}$ -inch spaces between the flats for ventilation. The relative humidity varied between 55 and 60 percent.

Monthly inspections were made until May 15, 1935, in the same manner and the same data were obtained as in 1933, except that no count was made of bulbs with roots and no soft or shriveled bulbs were discarded after March 15.

1934 COLD-STORAGE RESULTS

The percentage of sound bulbs shown in table 7 indicates that Italian Red was the first variety to lose an appreciable percentage of the original weight. The arrangement of varieties in the table is based on a combination of the March 15 and May 15 results with the poorest keepers at the top and the best at the bottom. Prizetaker and Sweet Spanish are placed high in the table, even though the percentage of sound bulbs would warrant a lower place, because the sound bulbs were of poorer quality due to bulging root plates and more incipient shriveling than occurred with the varieties below them in the table. These two varieties with Early Grano comprise the Sweet Spanish group and are better storage onions than Yellow Bermuda and Crystal Wax. California Early Red was a slightly better storage onion than these two latter varieties but slightly poorer than Early Grano. The Creole varieties lost weight in storage more rapidly than the commonly stored varieties (the remainder of table 7), but this may have been due to their very small size. Red Wethersfield was the least satisfactory of the common storage varieties and Australian Brown, White Portugal, and Ebenezer were the best. Bulbs grown from dry sets of Ebenezer and Golden Marvel stored as well or slightly better than bulbs of Ebenezer grown from seedlings.

Italian Red, Yellow Bermuda, and Crystal Wax had the largest number of bulbs with sprouts during the first 7 months of the storage period (table 8). White Creole, Ebenezer, and Australian Brown did not have a single sprouted bulb during the 9 months.

Italian Red had the greatest number of rotten bulbs during the storage period (table 9), while none of the bulbs of Red Creole and White Creole and only 1 percent of Australian Brown, Golden Marvel from dry sets, White Portugal, and Early Grano were discarded for this reason. During the early part of the storage period, most of the loss was due to neck rot, whereas during the latter part of the storage period most of the rotten bulbs had basal rot.

The bulbs that had been discarded because of softening, up to and including March 15, varied from 0 to 5 percent for all varieties except Yellow Bermuda, of which 11 percent were discarded. The very small percentages were not closely correlated with general keeping quality.

TABLE 7.—Percentage of the original weight of onion bulbs harvested at different dates and stored Aug. 16, 1934, that remained sound in cold storage at Arlington, Va., at each inspection, 1934-35

Variety	Strain No.	Original weight of 100 bulbs	Date harvested	Sound bulbs on inspection dates shown									
				Sept. 15	Oct. 16	Nov. 15	Dec. 15	Jan. 15	Feb. 15	Mar. 15	Apr. 15	May 15	
Italian Red.....	1	Lb. 10.3	July 11	Pct. 96.1	Pct. 84.5	Pct. 78.6	Pct. 72.8	Pct. 63.1	Pct. 55.3	Pct. 42.7	Pct. 34.0	Pct. 24.3	
Yellow Bermuda.....	3	14.1	July 3	96.5	85.8	81.6	78.0	65.2	51.8	36.2	25.5	16.3	
Crystal Wax.....	3	13.9	do	97.1	88.5	84.2	80.6	74.1	60.4	49.6	40.3	25.9	
California Early Red.....	1	10.4	July 7	97.1	93.3	88.5	83.7	78.8	71.2	66.3	59.6	43.3	
Early Grano.....	1	12.8	July 3	96.9	93.8	90.6	86.7	82.0	77.3	70.3	64.1	52.3	
Sweet Spanish.....	5	21.0	July 31	98.1	93.3	91.9	88.6	86.2	82.4	74.3	64.3	53.3	
Prizetaker.....	1	15.9	July 25	98.7	96.9	95.6	93.1	90.6	85.5	78.6	67.9	57.2	
Red Wethersfield.....	3	12.5	July 21	97.6	92.0	87.2	81.6	80.0	74.4	70.4	67.2	59.2	
Red Creole.....	1	3.1	June 25	96.8	93.5	87.1	83.9	80.6	74.2	71.0	67.7	61.3	
White Creole.....	1	3.6	do	97.2	94.4	91.7	86.1	83.3	77.8	72.2	69.4	66.7	
Early Yellow Globe.....	1	12.6	July 8	98.4	95.2	92.9	90.5	88.1	82.5	77.0	74.6	68.3	
Mountain Danvers.....	2	13.6	July 9	98.5	91.9	88.2	87.5	85.3	82.4	80.1	76.5	71.3	
Southport Red Globe.....	3	11.3	July 25	97.3	94.7	92.9	91.1	89.4	83.2	78.8	73.4	66.4	
Southport Yellow Globe.....	3	12.5	do	96.8	92.8	89.6	88.0	86.4	84.0	79.2	74.4	68.8	
Southport White Globe.....	2	10.9	July 11	96.3	93.6	92.7	90.8	89.0	85.3	81.7	78.9	72.5	
Yellow Danvers Flat.....	1	12.6	July 9	98.4	94.4	92.1	91.3	88.9	86.5	82.5	76.2	65.1	
Yellow Globe Danvers.....	3	12.9	July 11	98.4	93.8	92.2	90.7	89.1	82.9	80.6	76.0	72.9	
Ohio Yellow Globe.....	3	13.3	do	97.7	95.5	94.0	91.0	89.5	89.5	82.7	76.7	60.9	
Ebenezer.....	4	9.6	July 10	97.9	94.8	91.7	90.6	88.5	86.5	84.4	82.3	80.2	
Yellow Strasburg.....	1	10.6	July 9	99.1	97.2	97.2	93.4	92.5	89.6	86.8	82.1	75.5	
White Portugal.....	3	9.3	July 11	97.8	95.7	94.6	93.5	91.4	89.2	86.0	83.9	82.8	
Ebenezer (from sets).....	10	10.7	July 10	99.1	93.5	92.5	91.6	90.7	88.8	86.9	86.0	81.3	
Golden Marvel (from sets).....	18.0	do	do	97.8	96.7	93.9	92.8	91.7	90.6	88.3	86.7	81.1	
Australian Brown.....	3	10.7	July 25	99.1	96.3	95.3	93.5	92.5	90.7	88.8	86.9	85.5	

TABLE 8.—Percentage of the original number of onion bulbs stored Aug. 16, 1934, that was discarded between inspection dates because of sprouting in cold storage at Arlington, Va., 1934-35

Variety	Strain No.	Bulbs discarded between inspection dates shown				
		Sept. 15 and Nov. 15	Dec. 15 and Jan. 15	Feb. 15 and Mar. 15	Apr. 15 and May 15	Total
Italian Red.....	1	Percent 3	Percent 12	Percent 14	Percent 16	Percent 44
Yellow Bermuda.....	3	0	10	16	25	51
Crystal Wax.....	3	0	2	21	29	52
California Early Red.....	1	0	2	5	21	28
Early Grano.....	1	0	0	3	14	17
Sweet Spanish.....	5	0	0	2	20	22
Prizetaker.....	1	0	0	2	17	19
Red Wethersfield.....	3	1	3	2	8	14
Red Creole.....	1	0	0	0	1	1
White Creole.....	1	0	0	0	0	0
Early Yellow Globe.....	1	0	1	0	6	7
Mountain Danvers.....	2	0	0	0	6	6
Southport Red Globe.....	3	0	0	1	7	8
Southport Yellow Globe.....	3	0	0	3	5	8
Southport White Globe.....	2	0	0	0	1	1
Yellow Danvers Flat.....	1	0	0	0	12	12
Yellow Globe Danvers.....	3	0	0	0	2	2
Ohio Yellow Globe.....	3	0	1	3	18	22
Ebenezer.....	4	0	0	0	0	0
Yellow Strasburg.....	1	0	0	0	3	3
White Portugal.....	3	0	0	1	1	2
Ebenezer (from sets).....	10	0	0	0	2	2
Golden Marvel (from sets).....	18.0	1	0	1	4	6
Australian Brown.....	3	0	0	0	0	0

A comparison of the weight of discarded bulbs (table 10) with that of sound bulbs remaining (table 7) shows essentially the same grouping of varieties. Early Grano had a low percentage loss for the Spanish group and Ohio Yellow Globe had a high percentage for its position in the table. The Creole strains and Australian Brown were remarkably free from rots, sprouts, or shriveled and soft bulbs.

TABLE 9.—Percentage of the original number of onion bulbs stored Aug. 16, 1934, that was discarded at various inspection dates because of decay or rotting in cold storage at Arlington, Va., 1934-35, and percentage of rots that developed between harvest and the start of cold storage

Variety	Strain No.	Bulbs discarded on inspection dates shown					Total
		Rots (harvest to storage)	Sept. 15, Oct. 16, Nov. 15	Dec. 15, Jan. 15, Feb. 15	Mar. 15, Apr. 15, May 15		
		Percent	Percent	Percent	Percent	Percent	
Italian Red	1	29.9	9	1	6	16	
Yellow Bermuda	3	5.0	5	0	2	7	
Crystal Wax	3	7.9	4	0	0	4	
California Early Red	1	40.6	1	2	1	4	
Early Grano	1	4.6	0	0	1	1	
Sweet Spanish	5	14.6	3	1	1	5	
Prizetaker	1	8.2	0	0	3	3	
Red Wethersfield	3	27.0	7	0	0	7	
Red Creole	1	1.1	0	0	0	0	
White Creole	1	2.1	0	0	0	0	
Early Yellow Globe	1	16.9	2	1	1	4	
Mountain Danvers	2	19.6	4	0	0	4	
Southport Red Globe	3	36.9	1	0	2	3	
Southport Yellow Globe	3	19.2	5	0	1	6	
Southport White Globe	2	10.3	3	0	6	9	
Yellow Danvers Flat	1	13.0	2	0	4	6	
Yellow Globe Danvers	3	17.0	3	0	1	4	
Ohio Yellow Globe	3	11.7	1	0	1	2	
Ebenezer	4	10.7	4	1	0	5	
Yellow Strasburg	1	14.3	0	0	3	3	
White Portugal	3	16.0	1	0	0	1	
Ebenezer (from sets)		18.1	3	0	0	3	
Golden Marvel (from sets)		5.3	1	0	0	1	
Australian Brown	3	5.0	1	0	0	1	

The loss of weight of both sound and unsound bulbs for each monthly period in storage (table 11) increased in rate with increased length of storage up to 6 or 7 months for most of the varieties. Italian Red, Yellow Bermuda, and Crystal Wax had the highest rate of loss during the first 2 months of the storage period; the Creoles (Red and White), California Early Red, and Early Grano had a slightly lower rate. Sweet Spanish and Prizetaker lost weight (exclusive of discards) in storage no faster than several of the other varieties during the first half of the storage period, but the rate increased during the last half, resulting in a total percentage loss greater than for other varieties. Australian Brown, Golden Marvel from dry sets, Ebenezer, White Portugal, Southport White Globe, and Mountain Danvers had the lowest percentage losses in weight.

TABLE 10.—Percentage of the original weight of onion bulbs stored Aug. 16, 1934, that was discarded because of sprouting, rotting, or softening in cold storage at Arlington, Va., at each inspection, 1934-35

[See tables 8 and 9]

Variety	Strain No.	Bulbs discarded on inspection dates shown									
		Sept. 15	Oct. 16	Nov. 15	Dec. 15	Jan. 15	Feb. 15	Mar. 15	Apr. 15	May 15	Total
Italian Red	1	0.9	7.8	1.9	1.9	4.9	2.9	10.7	5.8	6.8	43.6
Yellow Bermuda	3	0	6.4	0	0	8.5	9.2	12.7	8.5	7.1	52.4
Crystal Wax	3	0	4.3	0	0	2.9	9.4	7.2	7.2	12.2	43.2
California Early Red	1	0	1.0	1.9	1.9	1.0	4.8	1.9	4.8	14.4	31.7
Early Grano	1	0	0	0	0	0	.8	1.6	2.3	7.0	11.7
Sweet Spanish	5	0	2.9	0	.9	0	1.4	2.4	7.1	6.7	21.4
Prizetaker	1	0	0	0	0	0	3.1	3.1	6.3	6.3	18.8
Red Wethersfield	3	0	3.2	3.2	4.0	0	3.2	1.6	1.6	5.6	22.4
Red Creole	1	0	0	0	0	0	0	0	0	3.2	3.2
White Creole	1	0	0	0	0	0	0	0	0	0	0
Early Yellow Globe	1	0	1.6	.8	0	1.6	3.2	3.2	.8	3.2	14.4
Mountain Danvers	2	0	5.1	2.2	0	0	.7	0	1.5	2.9	12.5
Southport Red Globe	3	0	.9	0	0	0	3.5	1.8	1.8	4.4	12.4
Southport Yellow Globe	3	2.0	2.9	2.0	0	0	0	2.9	2.9	3.9	16.6
Southport White Globe	2	1.8	.9	0	0	0	.9	1.8	.9	4.6	10.9
Yellow Danvers Flat	1	0	2.4	0	0	0	0	.8	4.0	7.9	15.1
Yellow Globe Danvers	3	.8	2.3	0	0	0	.8	0	.8	.8	5.5
Ohio Yellow Globe	3	0	.7	0	1.5	0	.7	3.0	3.0	11.3	20.2
Ebenezer	4	0	2.1	1.0	0	1.0	0	0	0	0	4.1
Yellow Strasburg	1	0	0	0	0	0	0	0	1.9	2.8	4.7
White Portugal	3	0	1.1	0	0	0	0	1.1	1.1	0	3.3
Ebenezer (from sets)	0	0	3.7	0	0	0	0	0	0	2.8	6.5
Golden Marvel (from sets)	1	1.1	0	1.7	0	0	0	.6	0	3.9	7.3
Australian Brown	3	0	.9	0	0	0	0	0	0	0	.9

TABLE 11.—Percentage loss in weight between inspection dates of sound and unsound onion bulbs stored Aug. 16, 1934, in cold storage at Arlington, Va., 1934-35

Variety	Strain No.	Loss in weight between inspection dates shown									
		Aug. 16 to Sept. 15	Sept. 15 to Oct. 16	Oct. 16 to Nov. 15	Nov. 15 to Dec. 15	Dec. 15 to Jan. 15	Jan. 15 to Feb. 15	Feb. 15 to Mar. 15	Mar. 15 to Apr. 15	Apr. 15 to May 15	Total
Italian Red	1	2.9	4.0	4.6	4.9	6.7	7.7	3.5	6.8	8.6	49.7
Yellow Bermuda	3	3.5	4.4	5.0	4.3	5.5	6.5	5.5	5.9	8.3	48.9
Crystal Wax	3	2.9	4.4	4.9	4.3	4.5	5.8	5.9	4.3	5.4	42.4
California Early Red	1	2.9	3.0	3.1	3.3	4.6	3.7	4.1	2.9	3.2	30.8
Early Grano	1	3.1	3.2	3.3	4.3	5.4	4.8	7.1	5.6	7.3	44.1
Sweet Spanish	5	1.9	1.9	1.5	2.6	2.7	2.8	6.9	3.8	6.7	30.8
Prizetaker	1	1.3	1.9	1.3	2.6	2.7	2.1	4.4	5.6	6.5	28.4
Red Wethersfield	3	2.4	2.5	1.7	1.8	2.0	3.0	3.2	2.3	3.6	22.5
Red Creole	1	3.2	3.3	6.9	3.7	3.8	8.0	4.3	4.5	4.8	42.5
White Creole	1	2.9	2.9	2.9	6.1	3.2	6.7	7.1	3.8	4.0	39.6
Early Yellow Globe	1	1.6	1.6	1.7	2.6	.9	2.7	2.9	2.1	4.3	20.4
Mountain Danvers	2	1.5	1.5	1.6	.8	2.5	2.6	2.7	2.8	2.9	18.9
Southport Red Globe	3	2.7	1.8	1.9	1.9	1.9	3.0	3.2	4.5	3.6	24.5
Southport Yellow Globe	3	1.6	1.7	1.7	1.8	1.8	2.8	2.9	3.0	3.2	20.5
Southport White Globe	2	1.8	1.9	1.0	2.0	2.0	3.1	2.1	2.2	2.3	18.4
Yellow Danvers Flat	1	1.6	1.6	2.5	.9	2.6	2.7	3.7	2.9	4.2	22.7
Yellow Globe Danvers	3	.8	2.4	1.7	1.7	1.7	6.1	2.8	4.8	3.1	25.1
Ohio Yellow Globe	3	2.3	1.5	1.6	1.6	1.7	(¹)	4.2	3.6	5.9	21.6
Ebenezer	4	2.1	1.1	2.2	1.1	1.1	2.4	2.4	2.5	2.5	17.4
Yellow Strasburg	1	.9	1.9	0	3.9	1.0	3.1	3.2	3.3	4.6	21.9
White Portugal	3	2.1	1.1	1.1	1.1	2.3	2.4	2.4	1.2	1.3	15.0
Ebenezer (from sets)	0	.9	1.9	1.0	1.0	1.0	2.1	2.1	1.1	2.2	13.3
Golden Marvel (from sets)	1	1.1	1.1	1.1	1.2	1.2	1.2	1.8	1.9	1.9	12.5
Australian Brown	3	.9	1.9	1.0	2.0	1.0	2.0	2.0	2.1	2.1	15.0

¹ Gain of 0.8 percent.

1934 COLD-STORAGE SUMMARY

Considering all the factors involved in storage quality, the varieties stored in the 40° F. room in 1934-35 might be placed in groups with reference to the practicability of storing them for various lengths of time as indicated below:

<i>Variety</i>	<i>Length of storage</i>
Italian Red.....	} Very short.
Yellow Bermuda.....	
Crystal Wax.....	
California Early Red.....	} Short.
Early Grano.....	
Sweet Spanish.....	
Prizetaker.....	
Red Creole.....	
White Creole.....	} Medium.
Red Wethersfield.....	
Early Yellow Globe.....	
Mountain Danvers.....	
Southport Red Globe.....	
Southport White Globe.....	
Southport Yellow Globe.....	
Yellow Danvers Flat.....	
Yellow Strasburg.....	
Ohio Yellow Globe.....	
Yellow Globe Danvers.....	} Long.
White Portugal.....	
Ebenezer.....	
Golden Marvel.....	
Australian Brown.....	

1934 ROOM-TEMPERATURE-STORAGE CONDITIONS AND RECORDS

After setting up the cold-storage experiment described in the preceding section, 200 bulbs of each available variety were selected and stored on August 23, 1934, in onion crates, one-half to seven-eighths full, in a well-ventilated head house of a greenhouse relatively low in humidity at a temperature of 65° to 75° F. The crates were stacked against the wall, shoulder high.

Inspections were made at monthly intervals through December in the same manner, and the same data were secured as described for the 1934 cold-storage experiments.

1934 ROOM-TEMPERATURE-STORAGE RESULTS

The varieties have been arranged in the tables with those that stored poorest at the top and those that stored best at the bottom, based on the average of all strains, of a given variety at the December 22 inspection date. The rank of any variety at the November inspection was very little different from that at the December inspection. The percentage by weight of sound onions (table 12) decreased most rapidly in the Italian Red and next fastest in the Wolska and California Early Red varieties with Crystal Wax and Yellow Bermuda also in the very poor storage class. Under the storage temperatures of this experiment, Australian Brown decidedly kept the best. Early Grano held up better than the other varieties in the Sweet Spanish group (Sweet Spanish and Prizetaker) for the first 2 months, but was then surpassed by Sweet Spanish and Prizetaker. Over the 4-

month period (to December 22) Prizetaker and Sweet Spanish kept better than the majority of the domestic storage varieties. The Creole varieties also retained a larger percentage of sound bulbs until December 22 than did most of the domestic storage varieties.

In most cases the residual lots of bulbs from the strains used in the cold-storage experiment were of smaller weight per 100 bulbs than were those from strains that were not used in the cold-storage test. Because of this difference in average bulb size it is not possible to determine whether the strain differences shown in table 13 were inherent or merely associated with the size of bulb.

TABLE 12.—Percentage of the original weight of onion bulbs harvested at different dates and stored Aug. 23, 1934, that remained sound in cold storage at Arlington, Va., at each inspection, 1934-35

Variety	Strain No.	Original weight of 100 bulbs	Date harvested	Sound bulbs remaining on inspection dates shown			
				Sept. 24	Oct. 23	Nov. 22	Dec. 22
		Lb.		Percent	Percent	Percent	Percent
Italian Red	1	6.9	July 11	39.6	9.4	0.0	0.0
Crystal Wax	1	13.8	July 3	65.2	17.6	2.0	0
Do	3	8.8	do	88.0	45.7	5.7	0
Yellow Bermuda	1	13.2	do	76.5	40.9	3.8	0
Do	3	8.5	do	88.2	46.4	7.0	0
California Early Red	1	5.3	July 7	36.8	22.6	6.3	0
Wolska	1	7.6	Aug. 14	29.6	13.0	7.4	4.6
Mountain Danvers	2	8.3	July 9	90.4	62.6	25.9	7.2
Do	3	12.4	do	93.5	69.8	29.0	6.8
Southport White Globe	2	10.5	July 11	89.5	61.0	35.2	11.0
Do	3	11.6	do	88.8	60.3	29.3	9.9
Red Wethersfield	3	7.1	July 21	90.4	65.2	36.5	15.6
Do	4	12.8	do	85.5	50.4	19.9	6.2
Early Grano	1	5.9	July 3	95.6	82.6	41.3	13.0
Southport Red Globe	2	11.6	July 25	84.9	56.9	31.0	12.5
Do	3	7.8	do	89.7	65.4	35.9	17.3
Ohio Yellow Globe	1	10.8	July 11	88.4	66.2	37.5	15.7
Do	3	12.0	do	91.7	76.3	44.8	15.4
Yellow Globe Danvers	3	9.0	do	95.6	77.8	50.0	26.6
Do	4	12.6	do	90.0	74.2	47.6	17.0
Yellow Strasburg	1	8.4	July 9	84.5	73.8	48.2	28.6
Do	2	9.0	do	88.9	75.6	44.4	16.6
Yellow Danvers Flat	1	10.1	do	90.1	74.4	48.8	24.1
Southport Yellow Globe	1	13.1	July 25	87.8	69.4	41.2	21.8
Do	3	11.9	do	89.9	79.0	51.2	31.9
Red Creole	1	1.4	June 25	93.2	79.4	44.9	24.1
White Creole	1	1.4	do	96.6	75.9	51.8	24.1
Early Yellow Globe	1	10.6	July 8	93.4	81.1	55.7	29.7
Prizetaker	1	16.5	July 25	91.7	75.6	49.1	28.2
Do	3	20.5	do	88.0	80.0	58.2	34.5
White Portugal	2	10.5	July 11	89.5	72.8	43.3	18.1
Do	3	9.2	do	90.7	80.8	66.6	47.0
Ebenezer	1	8.8	July 10	90.9	78.4	54.5	31.8
Do	4	6.4	do	91.4	83.7	76.7	60.4
Do	6	12.6	do	92.9	77.2	49.2	23.2
Sweet Spanish	4	19.8	July 31	86.4	75.5	65.4	48.7
Do	5	18.8	do	77.1	66.0	50.5	41.0
Australian Brown	2	11.2	July 25	94.6	90.2	85.7	75.9
Do	3	8.2	do	93.6	89.0	83.7	79.2
Do	4	12.0	do	92.9	87.5	78.7	70.8

By October 23 all varieties and strains contained one or more sprouted bulbs (table 13), with the largest percentages in those varieties near the top of the table and the smallest in those near the bottom. In the Sweet Spanish group of varieties, time of sprouting was correlated with time of maturity.

Rots developed during the entire storage period, as shown in table 14, but the losses were heaviest during the first month. In general the losses due to rotten bulbs before the storage period corresponded

to the losses during the storage period. The Creole varieties alone had no rotten bulbs during the 4-month storage period. The very high loss in the Wolska variety was doubtless due to the immature condition when pulled.

Unlike the material in cold storage, the rots in the onions in room-temperature storage developed mostly at the base. The infection undoubtedly took place in the field as there was some loss there from bottom rot in a number of varieties, and so much in the Italian Red that it was pulled before maturity in order to save it.

The percentage of rots that developed between harvest and the start of the storage period is a better index of strain differences in susceptibility or resistance to rotting than the development of rots during the 4-month storage period because it is based on field run material rather than selected samples. The data on rots between harvest and storage show small differences between strains except in Crystal Wax, Mountain Danvers, Red Wethersfield, Southport Red Globe, Yellow Strasburg, and Australian Brown.

TABLE 13.—Percentage of the original number of onion bulbs stored Aug. 23, 1934, that was discarded at each inspection because of sprouting, 1934-35

Variety	Strain No.	Bulbs discarded on inspection dates shown					Total
		Sept. 24	Oct. 23	Nov. 22	Dec. 22	Percent	
Italian Red.....	1	Percent 39.5	Percent 25.5	Percent 12.0	Percent 12.0	Percent 77.0	
Crystal Wax.....	1	6.5	33.5	18.0	2.0	60.0	
Do.....	3	1.5	34.0	48.0	8.0	89.5	
Yellow Bermuda.....	1	6.0	32.5	43.5	3.5	85.5	
Do.....	3	3.0	37.5	45.5	7.5	93.5	
California Early Red.....	1	2.9	16.4	28.2	17.1	64.6	
Wolska.....	1	14.2	7.8	5.6	7	28.3	
Mountain Danvers.....	2	3.0	22.5	39.0	19.0	83.5	
Do.....	3	1.5	18.0	40.0	24.5	84.0	
Southport White Globe.....	2	3.0	19.0	24.5	24.0	70.5	
Do.....	3	1.5	23.5	32.0	21.5	78.5	
Red Wethersfield.....	3	3.1	10.5	29.6	19.8	63.0	
Do.....	4	8.0	30.5	29.0	15.0	82.5	
Early Grano.....	1	1.3	6.4	35.3	31.4	74.4	
Southport Red Globe.....	2	3.5	17.5	5.5	14.0	40.5	
Do.....	3	2.5	11.0	23.5	21.0	58.0	
Ohio Yellow Globe.....	1	2.0	14.5	25.0	22.0	63.5	
Do.....	3	2.0	9.5	23.5	31.5	66.5	
Yellow Globe Danvers.....	3	0	5.5	23.0	23.5	52.0	
Do.....	4	3.0	8.0	18.5	29.5	59.0	
Yellow Strasburg.....	1	1.0	5.0	17.0	23.0	46.0	
Do.....	2	1.5	6.5	32.0	30.0	70.0	
Yellow Danvers Flat.....	1	3.0	9.5	23.0	23.0	58.5	
Southport Yellow Globe.....	1	3.0	10.0	25.0	19.5	57.5	
Do.....	3	2.5	4.5	25.0	22.5	54.5	
Red Creole.....	1	0	6.0	29.0	24.0	59.0	
White Creole.....	1	0	10.5	34.0	24.5	69.0	
Early Yellow Globe.....	1	1.0	5.0	20.5	25.0	51.5	
Prizetaker.....	1	3.0	7.5	21.0	21.5	53.0	
Do.....	3	1.5	2.5	16.0	23.5	43.5	
White Portugal.....	2	3.0	8.5	23.0	26.0	60.5	
Do.....	3	1.0	3.5	12.0	18.0	34.5	
Ebenezer.....	1	0	5.5	19.5	20.0	45.0	
Do.....	4	.5	1.0	4.5	11.5	17.5	
Do.....	6	0	4.5	21.5	27.0	53.0	
Sweet Spanish.....	4	1.0	2.0	5.5	14.5	23.0	
Do.....	5	2.5	2.0	12.0	8.5	25.0	
Australian Brown.....	2	0	.5	2.0	6.5	9.0	
Do.....	3	0	1.0	2.5	2.5	6.0	
Do.....	4	1.0	1.5	4.0	4.0	10.5	

TABLE 14.—Percentage of the original number of onion bulbs stored Aug. 23, 1934, that was discarded at each inspection because of decay or rotting in room-temperature storage at Arlington, Va., 1934-35, and percentage of rots that developed between harvest and the start of storage

Variety	Strain No.	Rots (harvest to storage)	Onions discarded on inspection dates shown				
			Sept. 24	Oct. 23	Nov. 22	Dec. 22	Total
Italian Red	1	Percent -29.9	Percent 12.5	Percent 5.0	Percent 0.0	Percent 0.0	Percent 17.5
Crystal Wax	1	16.8	9.0	3.5	1.5	0	14.0
Do	3	7.9	4.0	3.5	1.0	0	8.5
Yellow Bermuda	1	3.0	5.0	2.0	1.5	0	8.5
Do	3	5.0	.5	2.0	0	.5	3.0
California Early Red	1	40.6	20.6	8.2	1.8	.6	31.2
Wolska	1	56.2	59.2	4.2	.7	1.4	65.5
Mountain Danvers	2	19.6	2.0	.5	1.5	.5	4.5
Do	3	3.2	2.5	2.0	1.5	1.0	7.0
Southport White Globe	2	10.3	6.5	5.5	2.0	.5	14.5
Do	3	10.6	6.0	2.0	2.0	.5	10.5
Red Wethersfield	3	27.0	4.9	1.2	0	3.0	9.1
Do	4	20.6	4.5	.5	3.5	.5	9.0
Early Grano	1	4.6	.6	0	0	0	.6
Southport Red Globe	2	28.2	8.0	8.0	8.5	1.5	26.0
Do	3	36.9	5.5	5.5	4.5	.5	16.0
Ohio Yellow Globe	1	11.7	7.0	3.0	4.5	1.5	16.0
Do	3	13.1	4.5	2.5	3.0	1.0	11.0
Yellow Globe Danvers	3	17.0	3.5	2.5	2.0	2.0	10.0
Do	4	17.5	3.5	5.0	6.0	2.0	16.5
Yellow Strasburg	1	14.3	10.0	1.0	4.0	.5	15.5
Do	2	9.0	4.0	3.0	.5	1.5	9.0
Yellow Danvers Flat	1	13.0	3.5	1.5	3.5	1.0	9.5
Southport Yellow Globe	1	20.6	6.0	6.0	4.0	1.5	17.5
Do	3	19.2	4.5	2.0	2.5	2.5	11.5
Red Creole	1	1.1	0	0	0	0	0
White Creole	1	2.1	0	0	0	0	0
Early Yellow Globe	1	16.9	3.5	4.0	4.0	2.5	14.0
Prizetaker	1	8.2	3.5	3.5	5.5	.5	13.0
Do	3	2.1	7.0	2.0	4.0	1.0	14.0
White Portugal	2	16.0	4.0	5.5	1.5	0	11.0
Do	3	16.0	6.0	2.5	1.5	2.5	12.5
Ebenezer	1	14.5	6.0	2.0	4.0	3.5	15.5
Do	4	10.7	5.5	.5	.5	1.5	8.0
Do	6	12.1	3.5	8.0	4.0	1.0	16.5
Sweet Spanish	4	10.2	9.5	5.5	2.5	.5	18.0
Do	5	14.6	17.0	5.5	2.0	.5	25.0
Australian Brown	2	10.6	3.5	1.5	0	2.0	7.0
Do	3	5.0	4.0	0	1.5	.5	6.0
Do	4	11.6	7.0	1.5	4.0	2.0	14.5

The loss in weight due to discarded bulbs (sprouts and rots), table 15, was greatest during the first month in the Italian Red and Wolska varieties, although they were exceeded for the 4-month period by several other varieties. Australian Brown, Sweet Spanish, Ebenezer, and Red Creole had the smallest total loss in weight due to rotted and sprouted bulbs. The differences between varieties were not as great under the room-temperature-storage conditions as in cold storage.

The percentage loss in weight between inspection dates (due to respiration and water loss) was greatest for Wolska and Italian Red for the first month (table 16). Crystal Wax, Yellow Bermuda, California Early Red, and the Creoles had higher total percentage losses between inspection dates than most of the other varieties in the list, with Australian Brown, Early Yellow Globe, and White Portugal having the lowest percentage losses.

TABLE 15.—Percentage of the original weight of onion bulbs stored Aug. 23, 1934, that was discarded because of sprouting and rotting in room-temperature storage at Arlington, Va., at each inspection, 1934-35

Variety	Strain No.	Bulbs discarded on inspection dates shown				
		Sept. 24	Oct. 23	Nov. 22	Dec. 22	Total
		Percent	Percent	Percent	Percent	Percent
Italian Red	1	46.4	18.8	8.0	-----	73.2
Crystal Wax	1	25.8	30.8	13.3	1.6	71.5
Do	3	4.5	31.8	37.5	4.5	78.3
Yellow Bermuda	1	16.3	27.3	32.6	3.0	79.2
Do	3	7.6	32.9	35.3	4.7	80.5
California Early Red	1	12.2	16.7	31.1	12.2	72.2
Wolska	1	40.7	10.2	4.6	9	56.4
Mountain Danvers	2	4.8	21.7	32.5	15.7	74.7
Do	3	2.4	18.5	36.3	20.2	77.4
Southport White Globe	2	2.9	20.0	21.4	21.9	66.2
Do	3	6.9	21.5	28.4	16.8	73.6
Red Wethersfield	3	5.2	16.5	25.2	16.5	63.4
Do	4	9.4	28.5	27.0	12.1	77.0
Early Grano	1	2.2	6.5	32.3	22.8	63.8
Southport Red Globe	2	6.0	21.1	17.6	20.7	65.4
Do	3	3.8	16.6	25.6	16.0	62.0
Ohio Yellow Globe	1	9.2	14.8	25.0	19.9	68.9
Do	3	5.0	10.0	22.8	26.1	63.9
Yellow Globe Danvers	3	2.8	6.6	22.2	21.1	52.7
Do	4	5.5	10.3	23.0	28.2	67.0
Yellow Strasburg	1	9.5	3.6	19.6	16.6	49.3
Do	2	4.4	5.6	25.0	23.9	58.9
Yellow Danvers Flat	1	4.9	9.8	20.2	21.7	56.6
Southport Yellow Globe	1	8.4	12.2	23.3	18.3	62.2
Do	3	5.9	5.4	21.8	8.0	41.1
Red Creole	1	0	3.4	27.6	13.8	44.8
White Creole	1	0	10.3	20.7	20.7	51.7
Early Yellow Globe	1	3.8	7.1	21.2	23.1	55.2
Prizetaker	1	5.2	8.7	18.3	16.5	48.7
Do	3	8.0	3.2	15.8	19.5	46.5
White Portugal	2	5.7	10.0	25.7	22.8	64.2
Do	3	5.5	4.4	11.5	16.4	37.8
Ebenezer	1	4.5	6.8	19.3	18.8	49.4
Do	4	3.1	1.6	3.9	11.6	20.2
Do	6	2.4	9.1	19.4	22.2	53.1
Sweet Spanish	4	7.6	4.8	6.1	13.6	32.1
Do	5	13.6	5.8	12.8	7.7	39.9
Australian Brown	2	1.8	.4	1.8	6.2	10.2
Do	3	2.6	.8	3.8	2.6	9.8
Do	4	3.8	1.7	6.7	5.0	17.2

TABLE 16.—Percentage loss in weight between inspection dates of sound and unsound onion bulbs stored Aug. 23, 1934, at room temperature, at Arlington, Va., 1934-35

Variety	Strain No.	Loss in weight between inspection dates shown				
		Aug. 23 to Sept. 24	Sept. 24 to Oct. 23	Oct. 23 to Nov. 22	Nov. 22 to Dec. 22	Total
		Percent	Percent	Percent	Percent	Percent
Italian Red	1	14.0	26.1	18.2	-----	58.3
Crystal Wax	1	8.8	25.7	12.5	25.0	72.0
Do	3	7.1	11.3	6.9	18.8	44.1
Yellow Bermuda	1	9.2	11.1	9.8	17.7	47.8
Do	3	4.0	9.5	7.9	25.0	46.4
California Early Red	1	9.7	16.1	5.7	4.8	36.3
Wolska	1	29.0	22.6	4.4	21.5	77.5
Mountain Danvers	2	4.1	7.0	6.6	14.3	32.0
Do	3	3.5	5.4	6.1	6.1	21.1
Southport White Globe	2	3.6	9.3	6.4	7.6	26.9
Do	3	4.3	7.2	4.4	7.3	23.2
Red Wethersfield	3	3.8	9.0	4.2	11.8	28.8
Do	4	5.4	7.7	6.3	7.3	26.7
Early Grano	1	2.7	7.1	11.0	10.0	30.8
Southport Red Globe	2	4.6	8.2	14.2	6.1	33.1
Do	3	6.0	8.0	6.1	6.7	26.8
Ohio Yellow Globe	1	2.6	8.2	5.7	4.6	21.1
Do	3	3.1	5.6	11.1	8.0	27.8

TABLE 16.—Percentage loss in weight between inspection dates of sound and unsound onion bulbs stored Aug. 23, 1934, at room temperature, at Arlington, Va., 1934-35—Continued

Variety	Strain No.	Loss in weight between inspection dates shown					Total
		Aug. 23 to Sept. 24	Sept. 24 to Oct. 23	Oct. 23 to Nov. 22	Nov. 22 to Dec. 22		
Yellow Globe Danvers.....	3	Percent 2.4	Percent 11.3	Percent 6.7	Percent 5.6	Percent 26.0	
Do.....	4	4.4	5.8	4.7	5.2	20.1	
Yellow Strasburg.....	1	5.9	7.9	8.0	6.1	27.9	
Do.....	2	6.6	8.6	8.7	7.9	31.8	
Yellow Danvers Flat.....	1	4.6	6.1	7.0	6.3	24.0	
Southport Yellow Globe.....	1	4.0	6.2	6.8	3.4	20.4	
Do.....	3	4.3	6.4	7.7	21.1	39.5	
Red Creole.....	1	4.3	11.4	5.4	13.7	34.8	
White Creole.....	1	4.3	9.1	5.7	12.5	31.6	
Early Yellow Globe.....	1	2.6	6.3	5.1	4.8	18.8	
Prizetaker.....	1	3.0	8.0	10.8	7.2	29.0	
Do.....	3	3.9	5.5	7.6	7.1	24.1	
White Portugal.....	2	4.5	7.3	4.9	4.8	21.5	
Do.....	3	3.4	6.0	3.8	5.1	18.3	
Ebenezer.....	1	4.3	6.3	3.5	6.6	22.7	
Do.....	4	6.3	5.3	4.0	7.0	22.6	
Sweet Spanish.....	6	4.4	7.2	10.9	7.5	30.0	
Do.....	4	5.8	7.1	5.0	4.3	22.2	
Australian Brown.....	5	9.0	6.7	4.3	3.6	23.6	
Do.....	2	3.6	3.8	2.8	3.9	14.1	
Do.....	3	3.8	4.0	1.7	2.3	11.8	
Do.....	4	3.1	3.9	2.4	3.3	12.7	

1934 ROOM-TEMPERATURE-STORAGE SUMMARY

With respect to their ability to remain usable for different lengths of time when stored at room temperatures, the 1934 list of varieties may be grouped as follows:

Variety	Length of storage
Italian Red.....	} Very short.
Crystal Wax.....	
Yellow Bermuda.....	
California Early Red.....	
Wolska.....	
Early Grano.....	
Prizetaker.....	
Mountain Danvers.....	
Red Wethersfield.....	
Red Creole.....	
White Creole.....	} Short.
Sweet Spanish.....	
Southport White Globe.....	
Southport Red Globe.....	
Early Yellow Globe.....	
Ohio Yellow Globe.....	} Medium.
Yellow Globe Danvers.....	
Yellow Strasburg.....	
Yellow Danvers Flat.....	
Southport Yellow Globe.....	
White Portugal.....	} Long.
Ebenezer.....	
Australian Brown.....	

DISCUSSION OF ARLINGTON, VA., RESULTS

A comparison of the 1933 and 1934 results from cold storage shows a close agreement in the classification of the varieties with reference

to length of time they may be satisfactorily stored at 40° F. even though there was a marked difference in weather conditions during maturity, and a period approximately 3 weeks longer between harvest and storage for the 1933 than for the 1934 crop. The delay in starting the storage in 1933 may be partly responsible for the shortened storage life of Mountain Danvers and Early Yellow Globe in 1933 as compared with 1934. The favorable conditions for curing during 1934 are doubtless responsible for the better showing of White Portugal in that year. In no case was a variety shifted more than one group in either direction, and in most cases the variety fell in the same group in both years.

The 1934 results indicate that storage for a short time at a temperature of 65° to 75° F. will result in much the same classification with respect to storage quality as a much longer period at 40°. The superiority of Australian Brown and Sweet Spanish over certain other varieties in their respective length-of-storage groups appears greater at relatively high than at low temperatures.

The Wolska is a standard variety for winter storage purposes in the vicinity of Warsaw, Poland, but it was unable to mature under the conditions at Arlington, Va., probably because the days were too short. After harvest on August 14, the majority of the plants did not dry down normally but either continued to send out new top growth or rotted.

Onions grown from dry sets are usually considered to break down in storage sooner than those grown from seed. The 1934 results, however, indicate that when bulbs from dry sets mature at the same time as those from green plants, they are of equal storage quality.

DAVIS, CALIF.

1933 CULTURAL METHODS AND CONDITIONS

The seed for the 1933 bulb crop, with the exception of the varieties Early Grano, Italian Red, and California Early Red, was sown in coldframes at Davis, Calif., on November 29 and 30, and December 1, 1932. The seedlings made a slow growth during the winter and were set in a moist, fertile, muck soil at Terminous, Calif., from March 22 to 31, 1933. Plants were spaced 3 inches in rows 15 inches apart. Practically all of the plants survived. Very little rain fell after the plants were set, as is usual for the locality at that time of the year. The crop was subirrigated in accordance with the general practice in the Delta region. Climatic conditions were favorable and a good yield was obtained of all varieties.

California Early Red and Italian Red were seeded on raised beds at Davis in early September and transplanted in late November. Early Grano was also seeded in the open, and plants were set in the field March 28. All varieties at Davis were grown in rows 18 inches apart. Italian Red and California Early Red seedlings were spaced 4 inches apart in the row, and the Early Grano 3 inches. A surface irrigation was given about every 10 days after the first of April until the bulbs were fully developed. The soil was a Yolo silt loam.

At both Terminous and Davis, foliage diseases were absent, but there was a trace of pink root. A few onion maggots were present

at Terminous, but they did very little damage. Thrips were abundant at both locations but did not cause the bulbs to ripen prematurely.

The ripening of the crop at both Terminous and Davis proceeded normally. The onions were harvested when the foliage began to yellow, the date for each variety being given in table 17. Bulbs in both locations were pulled and placed in windrows with the tops protecting the bulbs from sunburn until well cured. In some cases the bulbs were placed in shallow slatted crates after removing from the windrows and before placing in storage.

1933 STORAGE CONDITIONS AND RECORDS

The bulbs selected within any one lot were of uniform size and free of wounds and rots insofar as could be determined by inspection. The mean weight per bulb is given in table 17.

All lots were stored in a fairly large constant-temperature room held at 52° F., a fan being used to circulate the air. A record of the relative humidity was not kept. Fifty bulbs of each strain were placed in a single layer in slatted trays. The relative positions of the different trays were changed occasionally.

The time from harvest to storage varied from 2 to 21 days (table 17) which undoubtedly had some influence on the storage results. After 90 days' storage the sprouted and rotted bulbs were counted and discarded and the sound bulbs weighed.

1933 RESULTS

Italian Red kept very poorly and was the only variety that did not have any sound bulbs at the end of the 90-day storage period. California Early Red and Prizetaker also kept poorly in storage, but both stored better than Italian Red. The varieties having the highest percentage of sound bulbs after the 90-day storage period were Mountain Danvers, Ebenezer, Australian Brown, Extra Early Yellow, and Early Grano. Some of these are not considered by the trade to be good storage types, and no doubt if the storage period had been extended for another 30 or 60 days there would have been some rearrangement among the varieties.

Most of the storage loss in 1933 was due to sprouting and in this respect there was a great difference between varieties and between strains of the same variety (table 17). Loss due to sprouting was greatest in the Italian Red variety. Strain No. 2 of Prizetaker had the next highest percentage of sprouted onions, but there was a difference of 30 in percentage between the two strains of this variety. A difference of 24 in percentage occurred between the two strains of California Early Red. There were no sprouted bulbs in Early Grano after 90 days of storage, and none in one strain each of Australian Brown and Yellow Strasburg.

Bulb rotting was most prevalent in Italian Red and Sweet Spanish. Some rotting occurred also in Prizetaker, Crystal Wax, Early Grano, Yellow Strasburg, and Yellow Danvers Flat, but in general it was confined chiefly to the mild-flavored varieties.

TABLE 17.—Mean weight per bulb, percentage of the original number of bulbs that sprouted or rotted and of the original weight of sound bulbs that remained in storage when onions were harvested on different dates and stored soon thereafter for 90 days at 52° F. at Davis, Calif., 1933

Variety ¹	Strain No.	Harvest date	Time from harvest to storage	Mean weight per bulb	Bulbs (by count)—		Sound bulbs remaining (by weight)
					Sprouted	Rotted	
Italian Red	1	July 13	Days 8	Pound 0.48	Percent 74	Percent 26	Percent 0
California Early Red	2	June 16	12	.61	38	2	51
Do.	1	June 23	5	.48	14	4	68
Prizetaker	2	Sept. 2	5	.38	44	4	48
Do.	3	do	5	.42	14	0	80
Ohio Yellow Globe	3	Aug. 9	21	.22	24	0	71
Sweet Spanish	4	Sept. 2	14	.53	16	10	73
Do.	5	do	14	.53	12	14	73
White Portugal	2	Aug. 3	19	.24	34	0	62
Do.	4	do	19	.24	6	0	89
Southport Yellow Globe	1	Aug. 17	13	.25	18	0	78
Do.	3	do	13	.20	24	0	78
Southport Red Globe	3	Aug. 9	21	.20	26	0	75
Do.	2	do	21	.18	14	0	84
Red Wethersfield	2	Aug. 7	18	.28	20	0	78
Do.	3	do	18	.25	18	0	80
Crystal Wax	2	July 6	9	.23	6	4	86
Do.	1	do	9	.23	8	0	88
Yellow Globe Danvers	2	Aug. 9	21	.26	18	0	80
Do.	5	do	21	.27	4	0	89
Yellow Strasburg	2	July 31	19	.17	4	4	86
Do.	1	do	19	.24	0	2	94
Yellow Bermuda	1	July 6	12	.22	2	0	90
Do.	2	do	12	.23	6	0	93
Yellow Danvers Flat	1	July 22	10	.24	4	2	92
Southport White Globe	3	Aug. 3	2	.21	6	0	90
Do.	2	do	2	.25	2	0	94
Early Grano	-----	June 28	7	.43	0	4	93
Extra Early Yellow	-----	July 22	10	.30	2	0	94
Australian Brown	4	Aug. 26	11	.22	2	0	94
Do.	3	do	11	.21	0	0	95
Ebenezer	6	July 31	4	.25	2	0	94
Do.	4	do	4	.24	2	0	96
Mountain Danvers	2	July 22	6	.24	2	0	96
Do.	3	do	6	.26	2	0	96

¹ Early Grano, California Early Red, and Italian Red bulbs were grown at Davis, Calif.; all others at Terminous, Calif.

1934 CULTURAL METHODS AND CONDITIONS

For the 1934 bulb crop, seeding, transplanting, and harvesting were done at the time indicated in table 18. All of the lots were grown at Davis. The seedlings were set in the field in rows 18 inches apart. All varieties transplanted in November and December were spaced 4 inches in the row, and those transplanted in January and February were spaced 3 inches. Surface irrigation was begun in April, and water was applied about every 10 days until the bulbs of any certain variety showed signs of maturity.

In the spring of 1934 there was a very severe attack of downy mildew. Many of the varieties, especially the late ones, did not mature normally. Most of the bulbs of the extra early varieties were well developed by the time mildew became severe, and therefore matured normally. Thrips became abundant later in the season, but the damage was not so severe as that caused by mildew.

TABLE 18.—*Dates of seeding, transplanting, and harvesting onions, mean weight per bulb, and percentage of bulbs that remained sound after different periods in storage at Davis, Calif., 1934-35*

Variety	Strain No.	Date seeded	Date transplanted	Harvest date	Mean weight of stored bulbs	Sound bulbs after number of days indicated				
						30	60	90	120	150
Italian Red.....	1	Sept. 4	Dec. 1	June 23	<i>l.b.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
Ohio Yellow Globe.....	3	Nov. 6	Feb. 20	July 20	0.33	56	22	5	0	0
Red Wethersfield.....	3	do	do	do	.22	98	75	30	7	1
Early Yellow Globe.....	1	Sept. 6	Dec. 8	June 18	.12	103	71	28	10	2
Southport Red Globe.....	3	Nov. 6	Feb. 21	July 21	.31	87	46	19	5	3
Mountain Danvers.....	2	do	Feb. 20	June 23	.15	93	55	16	9	6
White Sweet Spanish.....	1	do	Feb. 21	Aug. 1	.20	85	69	43	23	7
Prizetaker.....	1	do	do	July 21	.31	86	75	43	10	8
Southport Yellow Globe.....	3	do	do	do	.34	92	69	31	25	8
Yellow Danvers Flat.....	1	Nov. 8	Feb. 24	July 27	.15	96	75	43	18	8
Southport White Globe.....	2	Nov. 6	Feb. 21	July 21	.16	91	72	52	24	11
Yellow Globe Danvers.....	5	do	Feb. 20	July 20	.20	105	80	53	27	12
Ebenezer.....	6	Sept. 6	Dec. 8	July 9	.20	83	63	46	36	12
Yellow Strasburg.....	1	Nov. 6	Feb. 20	July 20	.17	109	74	59	31	14
California Early Red.....	1	Sept. 6	Nov. 21	June 7	.13	93	77	51	27	16
Yellow Bermuda.....	3	Oct. 3	Sept. 19	May 11	.48	83	73	52	24	18
Crystal Wax.....	3	do	Dec. 19	do	.29	88	78	51	37	19
Sweet Spanish.....	5	Oct. 10	do	Aug. 1	.27	96	89	71	41	24
White Portugal.....	3	Nov. 6	Feb. 20	July 20	.32	93	79	59	38	28
Early Grano.....	1	Sept. 5	Dec. 2	May 12	.13	94	73	59	37	29
White Creole.....	1	Oct. 3	Jan. 29	May 18	.40	85	88	80	67	34
Red Creole.....	1	do	do	do	.05	97	94	85	73	60
Australian Brown.....	3	Oct. 25	Feb. 26	Aug. 6	.07	99	96	86	78	67
					.10	87	94	92	90	87

¹ These lots increased in weight during the first 30 days of storage.

An effort was made to harvest the various lots at the same stage of maturity, but determining the proper stage was largely an approximation in the late varieties because of the injury from downy mildew. The bulbs were pulled and placed in burlap sacks and left lying in the field for 1 or more days to cure, then the onions were topped.

In most cases, 100 bulbs as free of rots and wounds as could be determined by inspection were selected for the storage test. The mean weight of the bulbs at time of storage is given in table 18.

1934 STORAGE CONDITIONS AND RECORDS

The onions were placed in shallow slatted-bottom crates in an onion warehouse with a slatted floor and free circulation of air beneath the floor. Windows on the side of the storage room were kept open. There was no forced circulation of air within the room.

Temperature and humidity records were taken in the storage house at 7 a. m. and 5 p. m. practically every day throughout the storage period, and the means for the 10-day periods are given in table 19. Both temperature and humidity conditions were far from uniform. Varieties stored early in the season were subjected to higher temperatures and lower relative humidities than those stored late.

1934 RESULTS

All lots were inspected after 30, 60, 90, 120, and 150 days in storage, and the percentage by count and weight of sprouted, rotted, and sound bulbs remaining at the end of each period was determined. Bulbs that were both sprouted and rotted were classed as rotted. The varieties are arranged in order according to the percentage by weight of sound bulbs remaining after 150 days of storage (table 18).

TABLE 19.—Average temperature and relative humidity in onion storage house for 10-day periods, Davis, Calif., 1934

Period	Temperature		Relative humidity	
	7 a. m.	5 p. m.	7 a. m.	5 p. m.
	°F.	°F.	Percent	Percent
May 17-26.....	60.1	79.2	71.3	47.0
May 27-June 5.....	61.1	75.0	69.0	53.5
June 6-15.....	65.6	85.2	72.3	50.2
June 16-25.....	63.0	87.5	67.0	37.1
June 26-July 5.....	68.3	94.4	62.9	33.8
July 6-15.....	64.3	91.7	68.4	34.8
July 16-25.....	63.2	86.0	73.6	42.3
July 26-Aug. 4.....	66.4	93.9	65.7	35.2
Aug. 5-14.....	63.6	91.7	73.4	35.7
Aug. 15-24.....	66.0	90.8	73.3	42.0
Aug. 25-Sept. 3.....	61.3	90.9	72.4	41.7
Sept. 4-13.....	64.3	90.4	70.5	41.8
Sept. 14-23.....	63.6	87.6	69.5	39.7
Sept. 24-Oct. 3.....	54.9	80.4	61.5	40.9
Oct. 4-13.....	57.3	79.3	74.2	53.9
Oct. 14-23.....	52.4	67.4	73.9	58.7
Oct. 24-Nov. 2.....	52.3	73.8	82.5	60.1
Nov. 3-12.....	50.7	67.8	88.2	74.4
Nov. 13-22.....	49.0	57.9	91.0	85.0
Nov. 23-Dec. 2.....	45.8	53.9	79.1	69.4
Dec. 3-12.....	44.0	59.3	65.4	56.2
Dec. 13-22.....	45.2	52.0	91.1	86.3
Dec. 23-26.....	41.6	44.2	92.0	93.0
Mean.....	57.6	77.4	74.3	52.7

Most of the varieties did not keep so well as was to be expected. This doubtless was due chiefly to the abnormal ripening of the bulbs caused by the very severe attack of mildew. As mentioned above, early varieties like Yellow Bermuda, Crystal Wax, Creole, and Early Grano were fairly well developed when the mildew attack came and the plants matured normally. In the late varieties, however, the early foliage was badly injured, causing most of the plants to mature with large, stiff, open necks. The storage results (table 18) show that many of the varieties, generally classified as poor storage onions, actually kept better than many varieties reputed to be good keepers.

Italian Red kept poorest again in 1934. After a storage period of 30 days, only 56 percent of the original sound bulbs remained, and after 90 days only 5 percent. The Australian Brown kept better than any other variety, even under the severe conditions of this test. Next best were the Red Creole and White Creole varieties.

Italian Red seems to be more susceptible to rot than any other variety (table 20). In most varieties rotting occurred during the early part of the storage period, but in California Early Red, Crystal Wax, and Early Grano, rotting was most prevalent during the latter part of the storage period. Rotting was most severe in Italian Red, California Early Red, Yellow Bermuda, and other varieties that have a mild flavor and a low percentage of dry matter. The least rot occurred in the Red Creole, White Creole, and Australian Brown, all highly pungent varieties. These observations suggest that components giving a high pungency may also have something to do with resistance to certain rot organisms.

TABLE 20.—Percentage of the original number of onions that was discarded because of rotting or sprouting in storage at Davis, Calif., 1934-35

ROTTED BULBS

Variety	Strain No.	Bulbs discarded after number of days indicated					
		30	60	90	120	150	Total
Italian Red.....	1	53	26	3	3	0	85
California Early Red.....	1	15	5	13	35	4	72
Early Yellow Globe.....	1	12	25	12	10	0	59
Yellow Bermuda.....	3	10	4	12	16	10	52
Early Grano.....	1	3	5	2	9	27	46
Mountain Danvers.....	2	9	12	16	6	1	44
Crystal Wax.....	3	2	3	3	15	14	37
Prizetaker.....	1	4	14	13	5	0	36
White Sweet Spanish.....	1	7	8	6	7	3	31
Yellow Globe Danvers.....	5	9	11	3	4	0	27
Southport Red Globe.....	3	1	11	10	3	0	25
Sweet Spanish.....	5	2	5	12	3	1	23
Ebenezer.....	6	2	18	0	1	0	21
Yellow Strasburg.....	1	3	14	0	2	0	19
Southport Yellow Globe.....	3	0	8	7	1	2	18
Ohio Yellow Globe.....	3	1	9	4	3	0	17
Red Wethersfield.....	3	2	10	2	0	2	16
White Portugal.....	3	0	12	0	2	0	14
Southport White Globe.....	2	1	4	5	1	1	12
Yellow Danvers Flat.....	1	2	3	3	0	0	8
Red Creole.....	1	0	0	1	0	1	2
Australian Brown.....	3	0	0	0	0	0	0
White Creole.....	1	0	0	0	0	0	0

SPROUTED BULBS

Ohio Yellow Globe.....	3	0	8	45	12	5	70
Southport Yellow Globe.....	3	0	9	25	24	11	69
Red Wethersfield.....	3	0	11	36	17	4	68
Yellow Danvers Flat.....	1	0	5	14	31	18	68
Southport White Globe.....	2	0	0	17	28	16	61
Yellow Globe Danvers.....	5	0	3	17	21	17	58
Yellow Strasburg.....	1	0	1	14	25	17	57
White Sweet Spanish.....	1	0	2	22	21	8	53
Southport Red Globe.....	3	0	12	33	4	3	52
Prizetaker.....	1	0	6	23	14	8	51
Ebenezer.....	6	0	0	9	21	19	49
Mountain Danvers.....	2	0	0	8	16	20	44
White Portugal.....	3	0	2	13	14	9	38
Early Yellow Globe.....	1	0	6	18	9	3	36
Sweet Spanish.....	5	0	0	6	17	8	31
Crystal Wax.....	3	0	0	3	12	14	29
Yellow Bermuda.....	3	0	0	1	3	18	22
Red Creole.....	1	0	0	0	0	15	15
White Creole.....	1	0	0	0	2	13	15
Italian Red.....	1	0	0	12	2	0	14
Early Grano.....	1	0	0	0	0	7	7
California Early Red.....	1	0	0	0	3	2	5
Australian Brown.....	3	0	0	0	0	1	1

The most striking feature of the 1934 storage test is the high percentage of sprouting bulbs among the typical storage varieties (table 20). This early sprouting must have been due to a poorly matured bulb as a result of severe mildew attack. Bulbs with thick open necks are regarded by the trade as being notoriously poor keepers.

The storage data for 1934 must not be considered typical, at least for the storage varieties. It is felt important, however, to show that abnormal growing conditions in the field often do affect profoundly the behavior of a given variety in storage.

SUMMARY OF DAVIS, CALIF., RESULTS

Because of the difference in date harvested, difference in prestorage interval, and the complicating factor of mildew it is unwise to make comparisons or draw conclusions concerning the keeping quality of onion varieties in the 1934 tests.

As the result of several years' observations and other experimental work in California, the varieties might be expected to remain usable for the following lengths of time after harvest:

<i>Variety</i>	<i>Length of storage</i>
Italian Red.....	Very short.
California Early Red.....	
Crystal Wax.....	Short.
Early Grano.....	
Prizetaker.....	
Yellow Bermuda.....	
Sweet Spanish.....	Short to medium.
White Sweet Spanish.....	
Early Yellow Globe.....	
Ebenezer.....	Medium.
Mountain Danvers.....	
Ohio Yellow Globe.....	
Red Wethersfield.....	
Southport Red Globe.....	
Southport White Globe.....	
Southport Yellow Globe.....	
White Portugal.....	
Yellow Danvers Flat.....	
Yellow Globe Danvers.....	
Australian Brown.....	Long.
Red Creole.....	
White Creole.....	

AMHERST, MASS. (1933)

CULTURAL METHODS AND CONDITIONS

Seed was sown in flats of sterilized soil in the greenhouse on January 20, 1933. On April 10 the plants were moved to an electrically heated hotbed where they remained until set in the field on May 9 and 10. The tops of the seedlings had been cut back to 3 inches in length on February 28, March 30, and April 15. The tops and roots were pruned before setting in the field and at this time the base of the plants ranged from one-eighth to one-third of an inch in diameter. The seedlings were set in rows 15 inches apart with the plants 3 or 4 inches apart, depending on the variety.

The field used had 5 tons per acre of well-rotted manure plowed under in the fall and a broadcast application of 1 ton per acre of a 5-8-7 fertilizer harrowed in just prior to setting the seedlings. The soil had a pH value of 6.3 and was a Merrimac sandy loam.

In spite of dry weather during part of May the plants made satisfactory growth. Because of a heavy thrips infestation early in June, two applications of nicotine dust and one of nicotine spray were made during June and July. Hot, dry weather during July favored the increase of thrips, and all varieties were severely damaged during the month except Prizetaker, Sweet Spanish, and White Sweet Spanish, which showed only moderate damage. August and early September were very unfavorable for proper maturity and drying because of frequent and heavy rainfall and high relative humidity. Each variety

was pulled soon after 60 to 75 percent of the tops had fallen over, placed in small windrows in the field to dry for a few days, topped, placed in slatted crates, and stored under cover to complete the curing process.

COLD-STORAGE CONDITIONS AND RECORDS

On September 28, 100 uniform, sound, well-matured bulbs typical of each variety were stored in slatted bushel crates in a 40° F. storage room with relative humidity of approximately 95 percent. Bulbs of Italian Red were not included, because all of the bulbs of this variety harvested had sprouted or rotted prior to this date. Inspections of the bulbs in the cold-storage room were made on October 6 and 20, and on November 14, at which date the experiment was concluded. Bulbs with new roots, one-eighth of an inch or longer, were recorded but not discarded, while those with visible new foliage (sprouts) or with evident decay were discarded at each inspection.

COLD-STORAGE RESULTS

The varieties are arranged in table 21 in accordance with the percentage (based on the original weight) of sound bulbs on November 14; the poorest storage varieties are at the top and the best at the bottom. White Sweet Spanish had the largest loss in weight during this relatively short storage period and was a much poorer storage variety than Sweet Spanish and Prizetaker. All the white varieties were poorer keepers than the yellow or red varieties having a similar maturity and shape, i. e., Crystal Wax was poorer than Yellow Bermuda; White Portugal, poorer than Red Wethersfield; Southport White Globe, poorer than Southport Red Globe. Except for Crystal Wax and Yellow Bermuda there seems to be a correlation between late maturity and poor storage quality.

TABLE 21.—Percentage of the original weight of onions harvested at different dates and stored Sept. 28, 1933, that remained sound at each inspection, and percentage loss or gain in weight between different dates in cold storage at Amherst, Mass., 1933

Variety	Original weight of 100 bulbs	Date harvested	Sound bulbs on inspection dates shown			Loss or gain in weight ¹ from—		
			Oct. 6	Oct. 20	Nov. 14	Sept. 28 to Oct. 6	Oct. 6 to Oct. 20	Oct. 20 to Nov. 14
			Percent	Percent	Percent	Percent	Percent	Percent
White Sweet Spanish.....	25.9	Sept. 2	94.6	78.3	36.7	-5.31	-1.02	-2.47
California Early Red.....	20.3	Aug. 25	98.5	80.0	46.8	-1.54	0	-3.46
Crystal Wax.....	11.6	Aug. 7	93.0	80.6	49.5	-5.38	-	-5.58
Yellow Bermuda.....	15.7	do.	98.8	82.9	57.4	-1.19	-	-0.87
White Portugal.....	18.7	Aug. 25	100.0	90.7	66.3	0	-	-6.67
Southport White Globe.....	21.3	do.	99.8	96.2	72.5	-	0	-2.44
Sweet Spanish.....	38.2	Sept. 2	97.8	97.8	81.2	-2.29	0	-3.04
Prizetaker.....	34.5	do.	98.6	99.3	84.0	-1.45	+ .73	0
Red Wethersfield.....	20.7	Aug. 25	96.6	96.0	87.9	-3.61	0	-1.57
Southport Red Globe.....	19.7	do.	100.0	99.6	88.5	0	0	- .69
Extra Early Yellow.....	22.0	Aug. 7	100.0	99.1	89.8	0	0	- .62
Australian Brown.....	17.6	Aug. 25	98.0	94.1	92.0	- .21	+ .36	- .81
Ohio Yellow Globe.....	19.6	do.	98.5	97.6	93.1	- .32	- .32	- .71
Yellow Danvers Flat.....	17.5	Aug. 14	100.0	100.0	94.3	0	0	- .77
Ebenezer.....	19.5	Aug. 7	101.3	100.6	95.5	+1.28	0	0
Early Yellow Globe.....	17.7	Aug. 3	99.6	97.8	95.7	+ .35	- .35	- .78
Yellow Globe Danvers.....	20.4	Aug. 9	101.7	101.7	96.2	+1.53	0	-2.71
Yellow Strasburg.....	19.1	Aug. 14	100.8	99.8	97.2	+ .71	0	- .33
Mountain Danvers.....	18.9	Aug. 7	100.3	100.3	99.3	+ .33	+ .33	- .99

¹ In cases where a gain in weight is indicated the condition was due to condensation of moisture and drip in the storage chamber.

The data in table 22 show that the greatest loss was caused by rotting of the bulbs, there being very few sprouted bulbs during this period of storage at 40° F. The data on new roots would seem to indicate that their appearance was an index of storage quality, as there is a good correlation between their appearance and the subsequent development of rotted and sprouted bulbs.

BARN-STORAGE CONDITIONS AND RECORDS

After the cold-storage material had been selected, the remaining sound and well-matured bulbs of each variety (all strains of a given variety bulked together), except Italian Red, Crystal Wax, and Yellow Bermuda of which there were no good bulbs left, were placed in slatted crates and stored in a tight barn where the temperature followed closely the outdoors fluctuations common at this time of year at Amherst, Mass. The daily mean temperatures varied between 40° and 65° F. with a relative humidity range of 60 to 75 percent.

TABLE 22.—Percentage of the original number of onion bulbs stored Sept. 28, 1933, that had sprouted or rotted in cold storage at Amherst, Mass., and percentage of the remaining bulbs that had new roots at each inspection

Variety	Bulbs with sprouts			Bulbs with new roots			Rotten bulbs		
	Oct. 6	Oct. 20	Nov. 14	Oct. 6	Oct. 20	Nov. 14	Oct. 6	Oct. 20	Nov. 14
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
White Sweet Spanish.....	0	0	1	54	71	57	0	18	41
California Early Red.....	0	0	1	93	85	52	0	19	34
Crystal Wax.....	0	1	8	76	71	98	1	11	25
Yellow Bermuda.....	0	0	1	91	89	78	0	18	23
White Portugal.....	0	0	0	4	6	21	0	9	24
Southport White Globe.....	0	0	1	25	50	44	0	4	24
Sweet Spanish.....	0	0	0	13	56	67	0	0	16
Prizetaker.....	1	1	1	19	39	53	0	0	12
Red Wethersfield.....	0	0	0	0	0	4	0	1	8
Southport Red Globe.....	0	0	0	0	0	0	0	1	11
Extra Early Yellow.....	0	0	0	2	3	3	0	1	10
Australian Brown.....	0	0	0	1	6	14	0	3	1
Ohio Yellow Globe.....	0	0	0	3	4	2	1	1	4
Yellow Danvers Flat.....	0	0	0	0	27	23	0	0	5
Ebenezer.....	0	0	0	4	16	13	0	1	5
Early Yellow Globe.....	0	0	0	8	8	7	1	2	1
Yellow Globe Danvers.....	0	0	0	1	3	3	0	0	4
Yellow Strasburg.....	0	0	0	4	4	21	0	1	3
Mountain Danvers.....	0	0	0	7	10	10	0	1	0

BARN-STORAGE RESULTS

These bulbs were not disturbed until November 14 at which time the data, as given in table 23, were obtained. There were no sound bulbs of California Early Red or White Sweet Spanish, and the percentage in Southport White Globe and White Portugal was very small. In contrast to this group of very poor-storage varieties, the good-storage group consisted of Australian Brown, Ebenezer, Southport Yellow Globe, Yellow Globe Danvers, Ohio Yellow Globe, and Early Yellow Globe in which 74 percent or more of the bulbs were salable.

California Early Red was the only variety in which the major portion of the loss was caused by sprouting. In all other varieties the greatest loss was from rotten bulbs and the percentage was very high in White Sweet Spanish, Southport White Globe, White Portugal, Sweet Spanish, Prizetaker, and Yellow Danvers Flat.

DISCUSSION OF AMHERST, MASS., RESULTS

The results of these studies of the two lots of the same material stored under different conditions for the same length of time are in close agreement with reference to the final standing in the list of varieties studied, although the percentage loss was greater in the barn-stored material. Using Red Wethersfield as a dividing line, both tables contain the same varieties (except Yellow Danvers Flat) down to this point and these certainly comprise the poorer storage varieties. In the good-storage group there is a slight shift in position, indicating that Australian Brown and Ebenezer might be better varieties for storing in a barn or shed for 6 weeks or so than Mountain Danvers, Yellow Danvers Flat, and Yellow Strasburg.

TABLE 23.—Percentage of the original number of bulbs that were sound, sprouted, or rotted after barn storage from Sept. 28 to Nov. 14, 1933, at Amherst, Mass.

Variety	Bulbs originally stored	Bulbs that were—		
		Sound	Sprouted	Rotted
	<i>Number</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
California Early Red.....	160	0.0	77.5	22.5
White Sweet Spanish.....	94	0	14.9	85.1
Southport White Globe.....	1,560	9.4	27.0	63.6
White Portugal.....	1,069	15.0	26.6	58.4
Sweet Spanish.....	1,402	44.4	4.6	51.0
Prizetaker.....	844	44.5	9.6	45.9
Yellow Danvers Flat.....	158	51.3	7.6	41.1
Red Wethersfield.....	1,460	55.5	16.7	27.8
Mountain Danvers.....	1,041	56.7	9.4	33.9
Yellow Strasburg.....	157	58.0	2.5	39.5
Extra Early Yellow.....	272	64.3	4.4	31.3
Southport Red Globe.....	1,620	67.6	8.6	23.8
Ohio Yellow Globe.....	1,494	74.4	10.4	15.2
Early Yellow Globe.....	165	75.8	4.8	19.4
Southport Yellow Globe.....	1,465	77.7	5.0	17.3
Yellow Globe Danvers.....	988	78.9	3.8	17.3
Ebenezer.....	1,586	79.8	2.8	17.4
Australian Brown.....	1,126	82.7	1.6	15.7

The very poor storage quality of White Sweet Spanish, California Early Red, White Portugal, and Southport White Globe may have been partly due to the fact that they were not pulled as promptly as the other varieties after 60 to 75 percent of the tops had fallen over. In most cases the varieties were pulled within 3 to 6 days of the date on which it was estimated that 60 to 75 percent of the plants had their tops over, but the interval was 8 days for White Sweet Spanish, 9 days for White Portugal, 9 days and 11 days for California Early Red and Southport White Globe, respectively. It also required 14 days to cure these varieties and this was a longer period than that required for the earlier maturing varieties. During this period the weather was rainy and very humid, so it is perhaps not abnormal that the percentage of infection and subsequent loss from rotting should be high, even though the bulbs were in slatted containers under cover in a well-ventilated barn.

SUMMARY OF AMHERST, MASS., RESULTS

The onion varieties as grown and cured at Amherst, Mass., in 1933 may be placed in the following groups with reference to the length of time they held up satisfactorily in barn storage and cold storage:

<i>Variety</i>	<i>Length of storage</i>
Italian Red ¹	} Very short.
Crystal Wax ¹	
Yellow Bermuda ¹	
California Early Red.....	
White Sweet Spanish.....	} Short.
White Portugal.....	
Southport White Globe.....	
Sweet Spanish.....	
Prizetaker.....	} Medium to long.
Red Wethersfield.....	
Yellow Danvers Flat.....	
Mountain Danvers.....	
Yellow Strasburg.....	
Extra Early Yellow.....	
Southport Red Globe.....	
Early Yellow Globe.....	
Ohio Yellow Globe.....	
Southport Yellow Globe.....	
Yellow Globe Danvers.....	
Ebenezer.....	
Australian Brown.....	

¹ No data for barn storage.

McGUFFEY, OHIO

1933 CULTURAL METHODS AND CONDITIONS

In 1933, seeds were sown in flats January 20, germinated in a greenhouse, and the seedlings grown at cool temperatures to transplanting size (one-eighth of an inch in diameter) in electric and hot-water heated hotbeds near the greenhouse at Columbus, Ohio. The plants were transplanted April 25 to muck soil at McGuffey, Ohio, that had received 750 pounds per acre of a 3-9-18 fertilizer, and were set 4 inches apart in rows 18 inches apart. Good yields were produced by most varieties. The bulbs were harvested about September 10.

1933 STORAGE CONDITIONS

Sound bulbs were selected from each variety and placed in cold storage at Columbus on October 28. The storage temperature fluctuated daily from 32° to 34° F. at 10 a. m. to 5 p. m., through a gradual rise during the night to a high of 45° to 50° before 8 a. m., and was 55° to 60° on Sundays and holidays. The relative humidity fluctuated from 88 to 92 percent when the temperature was 32° to 34°, down to 70 to 80 percent with the rise in temperature indicated above.

The onions were weighed at each inspection date, and the percentage by count and weight was determined for bulbs that were discarded because of decay, sprouting, or growth of roots.

1933 RESULTS

The data are presented in tables 24-26, inclusive. Yellow Globe Danvers proved to be the best keeping variety. Southport Red Globe and Southport Yellow Globe varieties also stood up well in storage. The poorest keepers in the order named were Prizetaker, Southport White Globe, Mountain Danvers, and Sweet Spanish.

The commonest cause of spoilage was the growth of new roots. This accounted for 29 to 85 percent of the discarded bulbs of all varieties. Prizetaker, Mountain Danvers, Australian Brown, and Ebenezer seemed to produce new roots more quickly than the other varieties. Southport White Globe produced far more sprouts than any of the other varieties. Losses due to decay were excessive only with the Sweet Spanish variety.

TABLE 24.—Percentage of the original weight of onion bulbs harvested about Sept. 10 and stored Oct. 28, 1933, that remained sound in cold storage at Columbus, Ohio, at each inspection, 1933-34

Variety	Original weight of 100 bulbs	Bulbs remaining on inspection dates shown					
		Nov. 25	Dec. 22	Jan. 27	Feb. 23	Mar. 31	Apr. 28
	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Prizetaker.....	29.0	93.8	89.3	86.6	62.1	18.3	0.0
Southport White Globe.....	22.8	91.7	83.8	78.9	64.4	38.2	0
Mountain Danvers.....	23.9	95.8	90.0	88.3	81.2	41.8	0
Sweet Spanish.....	35.4	98.9	96.3	93.2	79.1	51.1	4.2
Ohio Yellow Globe.....	23.9	97.9	92.9	87.0	82.0	62.3	22.6
Red Wethersfield.....	23.1	95.7	94.4	90.9	84.9	71.6	19.4
Ebenezer.....	24.7	98.4	95.5	95.1	93.1	75.7	18.2
Yellow Globe Danvers.....	27.8	97.5	95.7	92.8	89.6	75.9	42.8
Southport Yellow Globe.....	24.4	98.0	95.0	92.2	84.8	76.2	30.3
Southport Red Globe.....	22.3	95.5	95.0	92.8	91.9	77.6	31.4
Australian Brown.....	21.6	98.6	95.4	93.1	85.6	78.2	12.0
White Portugal.....	23.9	98.7	93.3	91.2	87.4	78.7	23.8

TABLE 25.—Percentage of the original number of onion bulbs stored Oct. 28, 1933, that was discarded at each inspection because of the growth of new roots, sprouting, or decay or softening in cold storage at Columbus, Ohio, 1933-34

BULBS DISCARDED BECAUSE OF GROWTH OF NEW ROOTS¹

Variety	Bulbs discarded on inspection date shown						
	Nov. 25	Dec. 22	Jan. 27	Feb. 23	Mar. 31	Apr. 28	Total
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Prizetaker.....				20	42	22	85
Southport White Globe.....				4	8	43	55
Mountain Danvers.....				4	34	43	81
Sweet Spanish.....				11	17	42	70
Ohio Yellow Globe.....				2	16	41	59
Red Wethersfield.....				1	5	54	60
Ebenezer.....				0	15	61	76
Yellow Globe Danvers.....				0	1	28	29
Southport Yellow Globe.....				2	5	31	38
Southport Red Globe.....				0	8	46	54
Australian Brown.....				5	4	73	82
White Portugal.....				1	7	59	67

¹ No bulbs with new roots on Nov. 25 and Dec. 22 and only 1 percent in Prizetaker on Jan. 27.

TABLE 25.—Percentage of the original number of onion bulbs stored Oct. 28, 1933, that was discarded at each inspection because of the growth of new roots, sprouting, or decay or softening in cold storage at Columbus, Ohio, 1933-34—Continued

BULBS DISCARDED BECAUSE OF SPROUTING

Variety	Bulbs discarded on inspection date shown						
	Nov. 25	Dec. 22	Jan. 27	Feb. 23	Mar. 31	Apr. 28	Total
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Prizetaker.....	3	0	0	1	2	1	7
Southport White Globe.....	4	7	2	9	17	1	40
Mountain Danvers.....	4	2	1	2	5	1	15
Sweet Spanish.....	0	1	0	0	6	0	7
Ohio Yellow Globe.....	1	1	0	2	5	1	10
Red Wethersfield.....	2	0	1	3	6	5	17
Ebenezer.....	0	0	0	3	0	1	4
Yellow Globe Danvers.....	2	0	1	2	2	2	9
Southport Yellow Globe.....	1	0	1	2	2	0	6
Southport Red Globe.....	2	0	1	0	5	0	8
Australian Brown.....	0	0	1	0	2	0	3
White Portugal.....	0	3	0	1	1	2	7

BULBS DISCARDED BECAUSE OF DECAY OR SOFTENING

Prizetaker.....	0	4	0	2	2	0	8
Southport White Globe.....	3	0	1	1	0	0	5
Mountain Danvers.....	0	2	0	0	2	0	4
Sweet Spanish.....	0	1	1	2	4	7	15
Ohio Yellow Globe.....	1	1	2	0	0	1	5
Red Wethersfield.....	0	0	1	0	0	0	1
Ebenezer.....	1	1	0	0	1	0	3
Yellow Globe Danvers.....	0	1	1	0	0	1	3
Southport Yellow Globe.....	0	2	2	1	0	0	5
Southport Red Globe.....	1	0	0	0	1	0	2
Australian Brown.....	1	2	0	1	0	0	4
White Portugal.....	1	1	0	0	2	0	4

TABLE 26.—Percentage loss in weight between inspection dates of onions stored Oct. 28, 1933, in cold storage at Columbus, Ohio, discarded bulbs excluded, 1933-34

Variety	Loss in weight between inspection dates shown						
	Oct. 28 to Nov. 25	Nov. 25 to Dec. 22	Dec. 22 to Jan. 27	Jan. 27 to Feb. 23	Feb. 23 to Mar. 31	Mar. 31 to Apr. 28	Total
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Prizetaker.....	2.8	0.4	2.0	0.8	2.8	0.0	8.8
Southport White Globe.....	1.4	1.0	2.1	1.2	2.0	0	7.7
Mountain Danvers.....	.4	.9	.9	.5	2.1	1.0	5.8
Sweet Spanish.....	1.1	.6	2.4	1.5	1.4	.6	7.6
Ohio Yellow Globe.....	.4	1.3	2.8	.5	2.0	.7	7.7
Red Wethersfield.....	1.8	1.4	.9	1.0	1.5	.6	7.2
Ebenezer.....	.4	1.6	.4	0	.9	.5	3.8
Yellow Globe Danvers.....	.7	1.1	.8	1.6	12.0	1.0	17.2
Southport Yellow Globe.....	1.2	.4	.4	1.8	1.4	.7	5.9
Southport Red Globe.....	.9	.5	1.0	1.0	1.5	.9	5.8
Australian Brown.....	.5	1.0	1.5	1.0	1.1	0	5.1
White Portugal.....	.4	.8	2.3	1.8	5.3	1.7	12.3

COLUMBUS AND MCGUFFEY, OHIO

1934 CULTURAL METHODS AND CONDITIONS

In 1934 seeds were sown on the same dates and under the same conditions as in 1933 (see p. 29).

In addition to a planting at McGuffey, onion seedlings were transplanted to rich silt loam soil at Columbus, Ohio, on April 23, 1934.

The soil received a 4-12-4 fertilizer at the rate of 1,000 pounds per acre. Water was applied by means of an overhead system as often as needed and an excellent yield was secured.

1934 STORAGE CONDITIONS

Bulbs were stored on November 1, 1934, under the same conditions provided in 1933.

1934 RESULTS

With the exception of Prizetaker, it is interesting to note that onions grown on muck soil at McGuffey stood up better in storage than those grown on silt loam soil at Columbus. (See tables 27 to 29.) It is not clear how much of this difference was due to the soil conditions and how much to other factors.

Red Wethersfield and Early Yellow Globe from McGuffey and Southport Yellow Globe from Columbus stood up best in storage. Prizetaker, Sweet Spanish, and Southport White Globe did not keep well. These same varieties had performed in a similar manner in 1933. White Portugal, White Creole, and Yellow Strasburg were also poor keepers. These three varieties were not included in the 1933 storage tests.

The growth of new roots again accounted for the greatest loss in storage. As in the previous test Southport White Globe showed the greatest loss due to sprouting, and Sweet Spanish the greatest loss (10 percent) due to decay or softening.

TABLE 27.—Percentage of the original weight of onion bulbs harvested about Sept. 10 and stored Nov. 1, 1934, that remained sound in cold storage at Columbus, Ohio, at each inspection, 1934-35

Variety	Place grown	Original weight of 100 bulbs	Sound bulbs remaining on inspection dates shown				
			Nov. 14	Dec. 12	Jan. 16	Feb. 13	Feb. 27
		<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Prizetaker.....	Columbus.....	30.7	25.4	13.0	5.9	0.0	0.0
Do.....	McGuffey.....	30.0	25.3	10.3	0	0	0
White Portugal.....	Columbus.....	20.1	49.8	29.4	4.5	0	0
Yellow Strasburg.....	do.....	16.5	46.1	21.2	6.7	0	0
White Creole.....	do.....	10.1	33.7	12.9	6.9	0	0
White Spanish.....	do.....	34.5	33.3	19.1	8.4	0	0
Mountain Danvers.....	do.....	22.0	55.9	25.4	14.5	1.8	0
Southport White Globe.....	do.....	15.9	67.9	28.9	12.6	0	0
Do.....	McGuffey.....	21.0	67.1	34.3	17.6	7.6	3.3
Yellow Danvers Flat.....	Columbus.....	12.2	60.7	36.1	17.2	2.5	0
Yellow Globe Danvers.....	do.....	19.3	61.1	41.4	23.8	8.8	4.2
Early Yellow Globe.....	do.....	24.4	42.6	21.7	7.8	2.5	0
Do.....	McGuffey.....	19.7	75.6	58.9	42.1	24.4	11.7
Australian Brown.....	Columbus.....	16.6	63.2	39.8	25.9	8.4	8.4
Ohio Yellow Globe.....	do.....	17.6	77.3	50.6	21.6	9.7	1.7
Do.....	McGuffey.....	23.2	76.3	62.1	38.4	19.0	9.9
Southport Red Globe.....	Columbus.....	18.3	76.5	50.8	32.8	17.5	9.8
Ebenezer.....	do.....	18.8	80.3	60.1	34.6	16.5	8.5
Red Wethersfield.....	do.....	21.2	89.6	61.3	32.5	6.1	0
Do.....	McGuffey.....	24.9	94.8	82.3	57.4	47.8	30.5
Southport Yellow Globe.....	Columbus.....	20.9	73.7	57.9	45.4	32.5	11.5

TABLE 28.—Percentage of the original number of onion bulbs stored Nov. 1, 1934, that was discarded at each inspection because of the growth of new roots, sprouting, or decay or softening in cold storage at Columbus, Ohio, 1933-34

BULBS DISCARDED BECAUSE OF GROWTH OF NEW ROOTS

Variety	Place grown	Bulbs discarded on inspection dates shown					
		Nov. 14	Dec. 12	Jan. 16	Feb. 13	Feb. 27	Total
		<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Prizetaker	Columbus	67	13	6	6	0	92
Do	McGuffey	72	12	9	0	0	93
White Portugal	Columbus	49	19	27	4	0	99
Yellow Strasburg	do	53	21	13	7	0	94
White Creole	do	65	22	5	6	0	98
Sweet Spanish	do	60	10	7	3	0	80
Mountain Danvers	do	44	25	7	10	3	89
Southport White Globe	do	27	28	11	13	0	79
Do	McGuffey	23	22	17	11	3	76
Yellow Danvers Flat	Columbus	33	24	17	17	5	96
Yellow Globe Danvers	do	37	17	16	14	5	89
Early Yellow Globe	do	45	20	15	7	3	90
Do	McGuffey	20	16	13	21	13	83
Australian Brown	Columbus	35	24	13	19	0	91
Ohio Yellow Globe	do	23	23	31	11	8	96
Do	McGuffey	13	16	24	21	10	84
Southport Red Globe	Columbus	20	22	27	13	7	79
Ebenezer	do	20	19	23	15	8	85
Red Wethersfield	do	9	23	29	24	6	91
Do	McGuffey	6	9	22	11	27	65
Southport Yellow Globe	Columbus	21	13	15	12	19	80

BULBS DISCARDED BECAUSE OF SPROUTING ¹

Prizetaker	Columbus	7	0	0	0	0	7
Do	McGuffey	4	1	1	0	0	6
White Portugal	Columbus	0	0	0	0	0	0
Yellow Strasburg	do	1	1	0	0	0	2
White Creole	do	0	0	0	1	0	1
Sweet Spanish	do	7	2	1	1	1	10
Mountain Danvers	do	3	2	1	2	0	8
Southport White Globe	do	10	6	2	0	0	18
Do	McGuffey	12	7	1	0	0	20
Yellow Danvers Flat	Columbus	2	0	0	1	0	3
Yellow Globe Danvers	do	3	0	2	1	0	6
Early Yellow Globe	do	5	1	0	0	0	6
Do	McGuffey	2	0	0	0	0	2
Australian Brown	Columbus	0	0	0	0	0	0
Ohio Yellow Globe	do	0	0	0	0	0	0
Do	McGuffey	2	1	0	0	0	3
Southport Red Globe	Columbus	4	1	0	3	0	8
Ebenezer	do	0	0	1	0	0	1
Red Wethersfield	do	2	1	0	3	0	6
Do	McGuffey	1	0	0	0	0	1
Southport Yellow Globe	Columbus	3	0	0	0	0	3

BULBS DISCARDED BECAUSE OF DECAY OR SOFTENING

Prizetaker	Columbus	0	0	0	1	0	1
Do	McGuffey	1	0	0	0	0	1
White Portugal	Columbus	0	1	0	0	0	1
Yellow Strasburg	do	3	1	0	0	0	4
White Creole	do	0	1	0	0	0	1
Sweet Spanish	do	0	3	4	3	0	10
Mountain Danvers	do	2	0	1	0	0	3
Southport White Globe	do	2	0	1	0	0	3
Do	McGuffey	0	1	0	0	0	1
Yellow Danvers Flat	Columbus	0	1	0	0	0	1
Yellow Globe Danvers	do	0	1	0	0	0	1
Early Yellow Globe	do	3	0	1	0	0	4
Do	McGuffey	2	1	1	0	0	4
Australian Brown	Columbus	0	1	0	0	0	1
Ohio Yellow Globe	do	0	0	1	0	0	1
Do	McGuffey	0	1	0	0	0	1
Southport Red Globe	Columbus	0	1	0	1	1	3
Ebenezer	do	0	0	0	1	0	1
Red Wethersfield	do	0	1	0	2	0	3
Do	McGuffey	1	0	1	0	1	3
Southport Yellow Globe	Columbus	1	1	0	1	2	5

¹ No sprouts on February 27 inspection.

TABLE 29.—Percentage loss in weight between inspection dates of onion bulbs stored Nov. 1, 1934, in cold storage at Columbus, Ohio, discarded bulbs excluded, 1934-35

Variety	Place grown	Loss of weight between inspection dates shown					Total
		Oct. 28 to Nov. 14	Nov. 15 to Dec. 12	Dec. 13 to Jan. 16	Jan. 17 to Feb. 13	Feb. 14 to Feb. 27	
		Percent	Percent	Percent	Percent	Percent	
Prizetaker.....	Columbus.....	0.0	1.3	2.5	0.0	0.0	3.8
Do.....	McGuffey.....	0	0	0	0	0	0
White Portugal.....	Columbus.....	0	1.0	0	0	0	1.0
Yellow Strasburg.....	do.....	0	1.8	7.1	0	0	8.9
White Creole.....	do.....	1.0	2.9	9.1	0	0	13.0
Sweet Spanish.....	do.....	.3	1.3	1.9	9.1	0	12.6
Mountain Danvers.....	do.....	.4	1.6	0	0	0	2.0
Southport White Globe.....	do.....	0	.9	3.0	5.0	0	8.9
Do.....	McGuffey.....	6.7	2.5	2.0	0	0	11.2
Yellow Danvers Flat.....	Columbus.....	.8	1.4	1.8	0	0	4.0
Yellow Globe Danvers.....	do.....	.5	0	1.2	0	5.9	7.6
Early Yellow Globe.....	do.....	0	0	2.8	0	0	2.8
Do.....	McGuffey.....	.5	.8	0	1.2	6.1	8.6
Australian Brown.....	Columbus.....	3.6	1.2	0	0	0	4.8
Ohio Yellow Globe.....	do.....	0	0	1.4	0	5.9	7.3
Do.....	McGuffey.....	4.3	0	.7	0	0	5.0
Southport Red Globe.....	Columbus.....	0	.7	1.4	0	3.1	5.2
Ebenezer.....	do.....	0	.7	.9	0	0	1.6
Red Wethersfield.....	do.....	.5	.5	.8	4.4	0	6.2
Do.....	McGuffey.....	0	.8	.6	0	0	1.4
Southport Yellow Globe.....	Columbus.....	0	0	0	0	2.3	2.3

SUMMARY OF OHIO RESULTS

On the basis of storage tests of bulbs grown at Columbus and McGuffey, the varieties can be classified as follows with reference to the time they held up satisfactorily in storage:

Variety	Length of storage
Yellow Strasburg.....	} Short (poor keepers).
White Portugal.....	
White Spanish.....	
Prizetaker.....	
White Creole.....	
Early Yellow Globe.....	} Medium (fair keepers).
Australian Brown.....	
Yellow Globe Danvers.....	
Yellow Danvers Flat.....	
Southport White Globe.....	
Mountain Danvers.....	} Long (excellent keepers).
Red Wethersfield.....	
Ohio Yellow Globe.....	
Southport Yellow Globe.....	
Ebenezer.....	
Southport Red Globe.....	

WINTER HAVEN, TEX.

1933 CULTURAL METHODS AND CONDITIONS

Seed of the White Sweet Spanish, Prizetaker, and Sweet Spanish varieties was sown in an open seedbed September 14, 1932; Crystal Wax and Yellow Bermuda varieties were planted in a similar way on September 20, 1933, at Winter Haven, Tex. Seedlings of all grew thriftily. On November 18 the varieties sown on September 14 were transplanted to the field in rows 18 inches apart and about 3½ inches apart in the row. Those first sown on September 20 were similarly transplanted on December 8. The tops of all plants were pruned to about 5 to 6 inches in length and were one-fourth to three-eighths of an inch in diameter at the base.

The soil on which they were grown was a Crystal fine sand; 1,200 pounds per acre of 6-12-3 fertilizer was broadcast about a week before the onions were set out and preceding the making of the ridges on which the onions were transplanted.

On the whole, growing conditions for onions were very good despite a serious freeze in February 1933. Although watered at more or less long intervals early in the season, beginning with April 7 the onions received on the average one irrigation a week by the ridge-and-furrow system until the time of harvest.

A report of the effects of the freeze referred to above has been published (13).⁵ While in a vigorously vegetative condition the onions were subjected in February to minimum temperatures of 18°, 21°, 34°, 26°, and 32° F. on successive days. Although the tops collapsed and lay flat on the ground, the majority of the plants finally recovered.

The air temperature was very high during May, June, and July (see table 30), and this was the period during which the longer-day varieties were maturing.

Pink root disease became a factor especially in May, June, and July after the early varieties had been harvested; thrips also became a serious pest beginning in March. Following the harvest of the Bermuda varieties in late April or early May, it was difficult to determine whether high air and soil temperatures, pink root disease, or thrips was having the most serious effect. The combined effect was very severe. It is believed that the storage quality of the few late onions that did mature was reduced by these conditions.

In 1933 Crystal Wax, Bermuda, and Yellow Bermuda were normal in size and quality, but the Sweet Spanish, White Sweet Spanish, and Prizetaker varieties were quite variable and averaged somewhat subnormal in size. Many of the bulbs showed signs of decay, especially around the root plate, but these were not placed in the storage test.

In harvesting onions in Texas the usual procedure is to pull all the onions when about 60 percent of the tops have begun to soften at the neck, irrespective of whether they have fallen over or not. Many onions thus harvested are somewhat immature. High air temperatures, low relative humidity, and a breeze often characterize the harvest period, so favoring rapid curing that frequently a crop is pulled, cured a few hours in windrows, clipped, sacked, and shipped all in the same day.

In these tests the Yellow Bermuda and the Crystal Wax varieties were handled in two ways: (1) In the usual commercial manner except that 80 percent of the tops had softened at the neck rather than the usual 60 percent; (2) by allowing the bulbs to remain in the ground until the tops had all fallen over and in many cases partially dried down. Those handled in the regular way were taken from strains 2 and 3 of Yellow Bermuda and strain 3 of Crystal Wax; those harvested when more mature were taken from Yellow Bermuda strains 1 and 4 and Crystal Wax strains 1, 2, and 4.

In the case of the Sweet Spanish, White Sweet Spanish, and Prizetaker onions very few plants softened at the neck and the tops of fewer still fell over, as only a small proportion of the plants bulbed satisfactorily. These varieties are not well adapted to south Texas conditions because of their long-day requirements for bulbing. They were finally harvested in mid-June because apparently the bulb growth

⁵ *Italic numbers in parentheses refer to Literature Cited, p. 47.*

had ceased and an unidentified decay had started at the base of some of the bulbs. The onions were cured in onion crates for about 2 weeks before storing.

So far as possible, bulbs of large or normal size and apparently healthy and uninjured were chosen for the storage tests; only in those varieties where such bulbs were scarce were small bulbs also used. In Crystal Wax, Yellow Bermuda, and Early Grano the bulbs ranged in diameter from 2 to 4 inches with only a few of the first two varieties over 3½ inches. The bulbs of Sweet Spanish, White Sweet Spanish, and Prizetaker had a diameter range of 1½ to 4 inches, but very few were over 3½ inches and a much greater proportion of the bulbs were small as compared with those of the Bermuda varieties. Because of the adverse conditions they were below average size and may also have been abnormal in other ways.

1933 STORAGE CONDITIONS

All the onions were stored in 1-bushel folding slat crates, which were placed in a dry storage room with a concrete floor in a single story, hollow-tile barn with open screened windows. There was neither cross ventilation nor fans to aid air circulation. Outside temperature and humidity data are given in table 30. Maximum temperatures inside the barn were around 5° to 6° lower. Ten crates varying from one-third to nine-tenths full were placed in closely adjacent stacks of three or four each, away from any walls. The frequency of recording data on the stored onions usually depended on a preliminary casual inspection in which the general amount of decay was determined. Whenever this was high a complete inspection was always made as soon as possible. In table 31 only 9 inspections are indicated, but there were 13 inspections in all. Data taken May 23, August 18, September 20, and October 23 were, for the purpose of the table, included with the data of the next inspection date.

TABLE 30.—*Temperature and average relative humidity records at Winter Haven, Tex.*

Year and month	Mean temperature	Average relative humidity ¹	Days with average relative humidity of 80 percent or over
	° F.	Percent	Number
<i>1933</i>			
May.....	82.7	59.2	2 1
June.....	83.4	53.7	1
July.....	88.2	60.1	3
August.....	85.5	67.7	5
September.....	84.7	70.1	2
October.....	76.6	70.4	3
November.....	65.0	68.7	3
December.....	61.9	65.1	3 1
<i>1934</i>			
May.....	79.0	60.4	0
June.....	86.9	54.1	0
July.....	87.2	59.2	2
August.....	86.9	61.8	1
September.....	82.0	69.2	2
October.....	76.3	66.4	1
November.....	67.0	68.4	5
December.....	56.6	80.5	16
<i>1935</i>			
January.....	59.0	74.2	12
February.....	58.5	66.4	4 8

¹ Average of daily readings taken at 6 a. m. and 6 p. m.

² After May 16.

³ Before December 8.

⁴ Before February 14.

In recording the number of onions with sprouts, only the sprouted bulbs without decay were classed as sprouted. Those with both decay and sprouts were classed as decayed, because bulbs injured by decay were apparently forced into early growth; hence the appearance of foliage could hardly be considered normal sprouting.

1933 RESULTS

The varieties are arranged in table 31 with the poorest storage varieties at the top and the best at the bottom, based on the percentage by weight of sound bulbs remaining after approximately 3½ months of storage. This takes the Bermuda varieties up to September 1, which is somewhat longer than these varieties are stored without refrigeration. The Spanish types of onions were placed in storage much later than the Bermuda and, if the inspection date of October 3 is considered, in an even shorter time a greater proportion of bulbs had been lost than in the case of the Bermuda varieties (table 31). Thus on the basis of the 1933 test at Winter Haven and with the material available, Crystal Wax appears to be the best keeper, Yellow Bermuda the next best, and Sweet Spanish, Prizetaker, and White Sweet Spanish rather poor keepers. Data elsewhere in this circular (p. 4) show the Bermuda varieties to be less satisfactory for storage than some of the northern varieties. The poor keeping quality of the Spanish varieties in this test was probably partly or entirely due to the adverse conditions under which they were grown and harvested.

The Bermuda onions that had been allowed to mature more fully lost in weight somewhat more rapidly than those harvested in the normal manner.

Onions without apparent signs of decay sprouted only occasionally, no variety showing appreciable sprouting before November 9. The two lots of Yellow Bermuda and one of Crystal Wax that sprouted before November 9 included the two lots that had been allowed to mature more fully in the field. The first sprouts appeared in these as early as June 28, but Yellow Bermuda No. 2, the other lot that sprouted before November 9, showed its first sprouts at the inspection of September 1, 3½ months after being placed in storage, or 4 months after harvest. White Sweet Spanish and Sweet Spanish first exhibited sprouts after 4 months of storage as compared with about 5½ months of storage for Yellow Bermuda No. 3 and Crystal Wax No. 3. Prizetaker No. 3 was the last to sprout (1.2 percent showing sprouting on December 8), but very few bulbs then remained.

All three of the Spanish varieties lost heavily from decay during the first 2 months. By September 1, White Sweet Spanish had lost a total of 83 percent of its bulbs from decay; Prizetaker No. 3 had lost 81 percent; and Sweet Spanish No. 6 had lost 80 percent. The Bermuda varieties lost from 27 to 43 percent of their bulbs from decay in the first 2 months of their storage period (to July 21).

TABLE 31.—Percentage of the original weight of sound bulbs remaining and of the original number of bulbs removed because of sprouting or because of decay, at each inspection date, for onions in barn storage at Winter Haven, Tex., 1933

SOUND BULBS REMAINING, PERCENTAGE OF ORIGINAL WEIGHT

Variety	Strain No.	Bulbs in test	Original weight of 100 bulbs	Date of maturity	Date of storage	Data for inspection dates shown								
						June			July 21	Aug. 5	Sept. 1	Oct. 3	Nov. 9	Dec. 8
						1	13	28						
White Sweet Spanish		No.	Ib.	June 13	July 3	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	
Prizetaker	3	81	50.1	do.	do.	---	---	---	79.4	56.6	12.4	7.8	4.8	3.2
Sweet Spanish	6	69	54.9	do.	do.	---	---	---	57.9	47.8	13.8	9.6	4.0	2.8
Yellow Bermuda	1, 4	254	26.8	Apr. 21 ¹	May 16	86.1	78.0	66.3	39.9	30.0	21.2	13.6	5.6	2.1
Do.	2	139	21.7	do. ²	do. ³	98.3	91.7	80.1	53.5	37.8	20.3	12.7	7.0	5.4
Do.	3	146	24.4	do. ²	do. ³	94.4	87.4	73.3	45.0	34.9	20.0	15.8	8.8	3.0
Crystal Wax	1, 2, 4	212	29.1	do. ¹	do. ³	74.9	66.8	58.1	36.0	24.4	16.6	12.1	9.0	3.0
Do.	3	119	21.1	do. ²	do. ³	94.0	90.0	82.1	52.2	39.5	28.4	20.4	12.4	5.6

BULBS REMOVED BECAUSE OF SPROUTING, PERCENTAGE OF ORIGINAL NUMBER

White Sweet Spanish	1	36	36.5	June 13	July 3	---	---	---	0.0	0.0	0.0	0.0	5.6	0.0
Prizetaker	3	81	50.1	do.	do.	---	---	---	0	0	0	0	0	1.2
Sweet Spanish	6	69	54.9	do.	do.	---	---	---	0	0	0	0	1.4	2.9
Yellow Bermuda	1, 4	254	26.8	Apr. 21 ¹	May 16	0.0	0.0	0.4	1.2	0	0.4	1.2	7.1	12.2
Do.	2	139	21.7	do. ²	do. ³	0	0	0	0	0	1.4	0.7	7.2	10.8
Do.	3	146	24.4	do. ²	do. ³	0	0	0	0	0	0	0	4.8	19.7
Crystal Wax	1, 2, 4	212	29.1	do. ¹	do. ³	0	0	0.5	0.5	0	0	0.5	5.2	10.8
Do.	3	119	21.1	do. ²	do. ³	0	0	0	0	0	0	0	5.0	12.6

BULBS REMOVED BECAUSE OF DECAY, PERCENTAGE OF ORIGINAL NUMBER

White Sweet Spanish	1	36	36.5	June 13	July 3	---	---	---	13.9	16.7	52.8	5.6	0.0	0.0
Prizetaker	3	81	50.1	do.	do.	---	---	---	37.0	8.6	35.7	4.9	6.2	1.2
Sweet Spanish	6	69	54.9	do.	do.	---	---	---	14.5	15.9	49.3	4.4	5.8	1.5
Yellow Bermuda	1, 4	254	26.8	Apr. 21 ¹	May 16	8.7	4.7	7.1	22.4	9.8	6.7	6.7	8.3	0
Do.	2	139	21.7	do. ²	do. ³	0	2.2	7.9	17.3	10.8	20.2	10.8	2.9	0
Do.	3	146	24.4	do. ²	do. ³	3.4	3.4	11.6	21.2	8.9	13.0	4.8	3.4	0
Crystal Wax	1, 2, 4	212	29.1	do. ¹	do. ³	22.2	5.2	7.6	15.6	10.4	8.0	4.7	5.0	0
Do.	3	119	21.1	do. ²	do. ³	1.7	0.8	8.4	18.5	11.8	6.7	5.9	9.2	0

¹ Harvested May 12.² Harvested April 28.³ Placed in preliminary storage May 2, but not counted and weighed until May 16.

1934 CULTURAL METHODS AND CONDITIONS

The procedure followed in 1933-34 was in general similar to that in 1932-33. The varieties of Sweet Spanish and White Sweet Spanish were planted in the seedbed August 23, 1933; Crystal Wax, Yellow Bermuda, and Early Grano were sown on September 19; strain M of Red Creole on September 22, and Red Creole No. 1, and White Creole on October 16. The two Spanish varieties were transplanted to the field November 10; the two Bermuda varieties, Early Grano and strain M of Red Creole, followed on December 19. Red Creole No. 1 and White Creole were transplanted January 4, 1934. All plants were transplanted without any pruning of the tops or roots. Plants of all varieties except the Creoles were about 14 to 18 inches from the base to the tip of the longest leaf, and had a diameter at the base of one-fourth to one-half inch, generally nearer the larger size. Plants of strain M of Red Creole were generally near the smaller size. The

Creole varieties planted in January were noticeably smaller than any of the plants of varieties transplanted earlier.

The soil of the plots in 1933-34 was Orelia fine sand and received an application of 6-12-0 fertilizer at the rate of 1,200 pounds per acre before the onions were set out.

Climatic and soil conditions were favorable for onions in the 1933-34 season. However, as in the preceding season, pink root and thrips became serious, especially after the early varieties (the Bermudas, Early Grano, and the Creoles) had been harvested, and before the late varieties had bulbed up.

In 1934, Crystal Wax, Yellow Bermuda, Early Grano, and Red Creole strain M were all of good size and quality for the respective variety. Sweet Spanish and White Sweet Spanish again showed a great range in size of bulb, and on the average were subnormal in size. Red Creole No. 1 and White Creole No. 1, although well adapted to South Texas, were unfortunately also subnormal in size, probably because they were planted rather late. Since they are short-day varieties they bulbed as early as usual but before reaching their normal size for this section.

Harvesting conditions and procedure were much the same as in 1933, except that all the Bermuda onions were harvested at the same time.

Selection of the material for storage was made with the same care as in 1933. The diameters of bulbs of Crystal Wax, Yellow Bermuda, and Early Grano were also much the same as in 1933. Although a few bulbs of Sweet Spanish and White Sweet Spanish had a diameter of 4 inches, some bulbs measuring as little as $1\frac{1}{2}$ inches across had to be taken. The diameter of Red Creole strain M was $1\frac{1}{2}$ to 3 inches, with very few above $2\frac{1}{2}$ inches. Red Creole No. 1 and White Creole No. 2 had very few normal bulbs with a diameter of more than 2 inches, and in order to get a sufficient quantity for storage some bulbs measuring only 1 inch had to be taken. The large numbers of splits, doubles, and seed stems in the Creole varieties greatly reduced the number of normal onions from which storage material could be selected.

For additional observations on Crystal Wax, a crate of fine Crystal Wax bulbs (labeled C in tables 32 and 33) from a neighboring farmer was also placed in storage. In general these bulbs had a better appearance than those of strains 3 and 4. The seed from which these bulbs had come had been planted October 25, 1933, and the seedlings transplanted to the field December 18. An application of 500 pounds per acre of 20-percent superphosphate had been made. The mature onions had been harvested April 21.

1934 STORAGE CONDITIONS

The same type of crate and the same storage room were used as in 1933. A cross draught of air was established by making screened openings in the wall opposite the windows. These openings connected with the passageway outside the storage room, and a few feet down the passage a door was always open to the outside.

In addition to the inspections indicated in tables 32 and 33, data were recorded on May 22 (included with June 12) and on June 27 (included with July 19).

At the beginning of the storage test most crates were full of bulbs, but of course they gradually became empty as the test proceeded.

1934 RESULTS

The varieties are arranged in tables 32 and 33, with the poorest keepers at the top and the best at the bottom, based on the percentage by weight of sound bulbs remaining after approximately 4 months of storage (September 10 for the Bermuda varieties). After 4 months storage (November inspection) very few if any bulbs of Sweet Spanish and White Sweet Spanish remained. Very few bulbs of Early Grano placed in storage nearly 2 weeks after the Bermuda varieties lasted as long as 4 months, there being only about 5 percent of the original weight left at that time, September 27. In contrast to these records the Creole varieties had about 60 to 70 percent of the original total weight of the onions still in good condition 4 months after being placed in storage. They were outstanding from August 17 onward. At the last two inspections, November 12, 1934, and February 14, 1935, White Creole No. 1 had a much greater percentage of its original weight remaining after the inspection than did the Red Creoles.

Thus White Creole, and next Red Creole, showed up as very good keeping onions for southwest Texas conditions in 1934, easily excelling all other varieties in the test that year. The Crystal Wax and Yellow Bermuda onions, although making a poor showing as compared with the Creole varieties, again kept better than Sweet Spanish and White Sweet Spanish. Early Grano, in test for the first time, proved to be among the poorest of keepers.

Table 32 shows the percentage of bulbs discarded for sprouting. No bulbs of Sweet Spanish showed foliage growth at all before the last were discarded on September 27. There was little chance for sprouting to occur in any but the Creole varieties after mid-September because nearly all bulbs had rotted. Only a few Creoles had sprouted as late as November.

Decay was an important factor in 1934, as was the case in 1933. The only varieties not seriously affected by decay during the first several months of storage were Red Creole No. 1 and White Creole (table 32), both having 2 percent or less of the bulbs decayed up to and including the inspection of November 12, approximately 5½ months after being placed in storage. Of the Bermuda varieties and strains only Crystal Wax No. 3 lacked decayed bulbs by June 12, a little more than a month after being placed in storage. From July to October all strains of these varieties lost many bulbs from decay. In just a month 92.3 percent of the bulbs of Sweet Spanish No. 5 and 64.2 percent of the White Sweet Spanish were lost from decay.

In 1934, data were collected to indicate how much of the loss in weight between inspections was due to a combination of respiration, evaporation, and probably a slight transpiration from new foliage when present, and how much was due to the removal of discarded bulbs at each inspection (table 33). Sweet Spanish and White Sweet Spanish lost much more weight during the first month of storage than any other varieties or strains. Part of this excessive loss was probably due to the immaturity of the bulbs at harvest. The high percentage of decaying bulbs doubtless contributed to such losses much more than normal bulbs would have. Early Grano, although similar to Sweet Spanish, developed and matured under more favorable weather conditions because of its shorter length-of-day requirements and lost

weight about the same as Crystal Wax and Yellow Bermuda. Early Grano, however, lost rapidly during the first few inspections from the removal of decayed bulbs, as did Sweet Spanish and White Sweet Spanish. Red Creole No. 1 and White Creole No. 1 lost less weight between inspections than any other variety.

TABLE 32.—Percentage of the original weight of sound bulbs remaining, and of the original number of bulbs removed because of sprouting or because of decay, at each inspection date, for onions in barn storage at Winter Haven, Tex., 1934

SOUND BULBS REMAINING, PERCENTAGE OF ORIGINAL WEIGHT

Variety	Strain No.	Bulbs in test	Original weight of 100 bulbs	Date of maturity	Date of storage	Data for inspection dates shown							
						June 12	July 19	Aug. 17	Sept. 10	Sept. 27	Oct. 17	Nov. 12	Feb. 14
						Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Sweet Spanish	5	26	32.60	July 3	July 19	---	---	7.1	3.5	0.0	0.0	0.0	0.0
Early Grano	B 100	100	33.50	Apr. 20	May 17	68.7	37.3	14.0	6.3	4.8	1.5	0	0
White Sweet Spanish	1	53	24.00	July 3	July 19	---	---	27.3	17.2	12.5	7.0	2.3	0
Crystal Wax	3	35	19.20	Apr. 17	May 5	85.9	49.0	28.2	14.8	9.0	4.5	0	0
Do	4	80	18.70	do	do	83.3	54.0	32.0	18.7	14.7	7.3	0	0
Do	C 200	18.25	Apr. 21	do	do	86.3	46.0	24.7	16.4	13.4	10.7	4.9	0
Yellow Bermuda	3	100	22.75	Apr. 17	do	87.0	48.4	32.1	22.0	18.2	8.4	0	0
Red Creole	M 70	10.00	May 15	May 28	do	89.3	74.3	72.8	60.0	57.1	44.3	32.9	2.1
Do	1	100	4.30	do	do	93.0	83.7	81.4	74.4	72.0	65.1	48.8	10.5
White Creole	1	135	3.18	do	do	93.0	83.7	81.4	72.1	69.8	67.4	58.1	17.4

BULBS REMOVED BECAUSE OF SPROUTING GROWTH, PERCENTAGE OF ORIGINAL NUMBER

Sweet Spanish	5	26	32.60	July 3	July 19	---	---	0.0	0.0	0.0	0.0	0.0	0.0
Early Grano	B 100	100	33.50	Apr. 20	May 17	0	0	0	2.0	1.0	3.0	0	0
White Sweet Spanish	1	53	24.00	July 3	July 19	---	---	0	0	0	0	1.9	0
Crystal Wax	3	35	19.20	Apr. 17	May 5	0	0	0	0	2.9	5.7	0	0
Do	4	80	18.70	do	do	0	0	1.3	2.5	2.5	5.0	0	0
Do	C 200	18.25	Apr. 21	do	do	0	0	0	1.0	0	1.0	6.0	0
Yellow Bermuda	3	100	22.75	Apr. 17	do	0	0	0	5.0	2.0	5.0	0	0
Red Creole	M 70	10.00	May 15	May 28	do	0	0	0	0	0	1.4	8.6	50.0
Do	1	100	4.30	do	do	0	0	0	0	0	0	2.0	45.0
White Creole	1	135	3.18	do	do	0	0	0	0	0	0	0	29.6

BULBS REMOVED BECAUSE OF DECAY, PERCENTAGE OF ORIGINAL NUMBER

Sweet Spanish	5	26	32.60	July 3	July 19	---	---	92.3	3.9	3.9	0.0	0.0	0.0
Early Grano	B 100	100	33.50	Apr. 20	May 17	25.0	33.0	23.0	6.0	1.0	4.0	0	0
White Sweet Spanish	1	53	24.00	July 3	July 19	---	---	64.2	9.4	3.8	7.6	5.7	0
Crystal Wax	3	35	19.20	Apr. 17	May 5	0	34.3	20.0	14.3	5.7	2.9	0	0
Do	4	80	18.70	do	do	20.0	25.0	23.8	12.5	1.3	6.3	0	0
Do	C 200	18.25	Apr. 21	do	do	5.5	32.5	18.0	5.5	2.5	1.5	2.0	0
Yellow Bermuda	3	100	22.75	Apr. 17	do	3.0	30.0	15.0	5.0	3.0	7.0	0	0
Red Creole	M 70	10.00	May 15	May 28	do	0	14.3	0	5.7	0	1.4	8.6	10.0
Do	1	100	4.30	do	do	0	0	0	0	0	2.0	1.0	22.0
White Creole	1	135	3.18	do	do	0	0	0	0	.7	0	0	25.9

More weight was lost by the Sweet Spanish, White Sweet Spanish, and Early Grano varieties due to the removal of discarded bulbs than by any other varieties (table 33), and most of this loss occurred early in the storage period. Such losses in Red Creole strain M were practically absent, and in Red Creole No. 1 and White Creole No. 1 did not occur at all until very late in the storage period. The Bermuda varieties were between the two extremes in loss in weight due to discarded bulbs. Their losses at first were moderate, then increased during July and August.

SUMMARY OF WINTER HAVEN, TEX., RESULTS

Although the Creole varieties were tested only in 1934, their record in storage was so much better than that of the other varieties that it seems fairly safe to emphasize their good storage qualities. The varieties tested in both years behaved very similarly in the two seasons. Although records at Winter Haven and elsewhere indicate Crystal Wax and Yellow Bermuda to be poor keepers, in these tests these varieties kept better than Early Grano, Sweet Spanish, White Sweet Spanish, and Prizetaker. In south Texas the three last-mentioned varieties bulb up, if at all, under such unfavorable conditions that the storage quality of the bulbs is poorer than that of the Bermuda varieties.

TABLE 33.—Percentage loss in weight between inspection dates and percentage of original weight lost in the discarded bulbs at each inspection date for onions in barn storage at Winter Haven, Tex., 1934

PERCENTAGE LOSS IN WEIGHT BETWEEN INSPECTION DATES

Variety	Strain No.	Bulbs in test	Original weight of 100 bulbs	Date of maturity	Date of storage	Data for inspection dates shown								
						June 12	July 19	Aug. 17	Sept. 10	Sept. 27	Oct. 17	Nov. 12	Feb. 14	
						Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	
Sweet Spanish	5	26	32.60	July 3	July 19	---	---	41.2	33.3	33.3	---	---	---	---
Early Grano	B	100	35.50	Apr. 20	May 17	10.4	11.4	16.8	21.3	14.3	6.8	---	---	---
White Sweet Spanish	1	53	24.00	July 3	July 19	---	---	23.4	14.3	13.6	0	22.2	---	
Crystal Wax	3	35	19.20	Apr. 17	May 5	14.4	19.2	12.1	15.8	20.0	16.7	---	---	
Do	4	80	18.70	do	do	12.1	25.1	19.8	16.7	10.7	9.1	---	---	
Do	C	200	18.25	do	do	9.2	15.1	11.9	18.9	8.3	4.1	17.9	---	
Yellow Bermuda	3	100	22.75	Apr. 21	do	11.4	15.8	10.9	11.0	10.0	19.5	---	---	
Red Creole	M	70	10.00	May 15	May 28	10.7	15.9	1.9	9.8	4.8	15.0	12.9	26.1	
Do	1	100	4.30	do	do	7.0	10.0	2.8	8.6	3.1	6.5	21.4	14.3	
White Creole	1	135	3.18	do	do	7.0	10.0	2.8	11.4	3.2	6.5	13.8	28.0	

PERCENTAGE OF ORIGINAL WEIGHT LOST IN THE DISCARDED BULBS

Sweet Spanish	5	26	32.60	July 3	July 19	---	---	51.8	1.2	2.4	---	---	---
Early Grano	B	100	35.50	Apr. 20	May 17	20.9	24.5	17.0	4.8	.6	3.0	---	---
White Sweet Spanish	1	53	24.00	July 3	July 19	---	---	49.2	6.3	2.3	5.5	2.7	---
Crystal Wax	3	35	19.20	Apr. 17	May 5	0	22.2	14.8	8.9	3.0	3.0	---	---
Do	4	80	18.70	do	do	5.0	10.7	11.3	8.0	2.0	6.0	---	---
Do	C	200	18.25	Apr. 21	do	4.8	28.8	15.9	3.6	1.6	2.2	3.8	---
Yellow Bermuda	3	100	22.75	Apr. 17	do	2.0	25.9	11.0	6.6	1.8	6.2	---	---
Red Creole	M	70	10.00	May 15	May 28	0	1.4	0	5.7	0	4.3	5.7	22.1
Do	1	100	4.30	do	do	0	0	0	0	0	2.3	2.3	31.4
White Creole	1	135	3.18	do	do	0	0	0	0	0	0	0	24.4

DISCUSSION

Considering the wide range of conditions under which the various crops were produced and matured as well as the variation in length of time between harvest and storage, and conditions under which they were stored, there is, in general, a remarkable agreement in the storage rating or storage quality of the varieties and strains tested. In every location where it produced bulbs the Italian Red variety proved to be the poorest keeper due to its extreme susceptibility to rot organisms. California Early Red, Crystal Wax, and Yellow Bermuda had lower losses than Italian Red; and in all trials where it was included, Cali-

fornia Early Red rotted and sprouted quicker than Yellow Bermuda or Crystal Wax. These data therefore confirm the statement (10) that Italian Red and California Early Red do not keep well.

The differences between Yellow Bermuda and Crystal Wax were small at all locations and not consistently in favor of either variety. The results of these trials confirm the reputation of these varieties as poor keepers. The effect of mildew on the late varieties in California in 1934 and the amount of loss that occurred between harvest and storage in both 1933 and 1934 must be taken into account in evaluating these data. The Arlington data for 1933 show heavy losses (21 and 34 percent) during the 60-day period in storage in the head house of a greenhouse between harvest and the beginning of the cold storage period. In 1934 the loss during the 43-day period in house storage prior to cold storage was very low (5 and 8 percent). The losses in cold storage were higher in 1934 than in 1933. The Texas data show that holding the onions in house storage much over a month is likely to result in heavy shrinkage. Earlier data from Texas (8) would indicate that good sound bulbs might be held for about 70 days, but that test did not take into account weight loss by evaporation and transpiration and the bulbs were not stored under comparable conditions but lots of 25 bulbs were kept in paper bags. Growers in Collin County, Tex. (7) are reported to store for 4 or 5 months in cold storage and the Arlington data also suggest that this may be commercially feasible if sound, well-matured bulbs are stored at 32° or 40° F. and the price increases enough to pay for storage and handling costs.

The group of varieties of Spanish origin composed of Early Grano, Prizetaker, White Sweet Spanish, and Sweet Spanish do not keep as well as most of the domestic-type varieties. Early Grano is the poorest keeper of the group and is only slightly better than the Bermudas, in whose date-of-maturity group it belongs. Curry's (5) figure of 5-percent loss at the end of 30 days at 35° to 40° F. and 78 to 80 percent relative humidity also indicates that it is a poor storage variety, and his 2.5 percent loss in weight agrees closely with the 1934 Arlington figure of 3.1 percent in 40° storage. White Sweet Spanish was grown and stored only in 1933 at Arlington, Va., Winter Haven, Tex., and Amherst, Mass. At Arlington it was a slightly better keeper than Sweet Spanish and Prizetaker, but at Amherst and Winter Haven it was poorer. There was little difference in storage quality between Sweet Spanish and Prizetaker in any trial. Wilson's (17) results show Sweet Spanish to average slightly but not consistently better than Prizetaker. Storage experiments conducted in Indiana (4) for 4 months showed Sweet Spanish to store less satisfactorily than Southport Yellow Globe or Southport White Globe.

In most of the trials the greatest loss in marketability of the Spanish type varieties was due to rotting and loss in weight while in storage. They were slow to form sprouts.

The so-called domestic varieties or those commonly grown for storage purposes are definitely better for long storage than the Spanish, Bermuda, or California Early Red varieties. Australian Brown and the Creoles (Red and White) seem to be especially adapted for long storage in barns or sheds in regions where temperatures are relatively high. They also keep well when placed in cold storage but are fre-

quently surpassed by other varieties. Other varieties commonly found in the group of long-storage varieties are Yellow Globe Danvers, Yellow Danvers Flat, Yellow Strasburg, Ebenezer, White Portugal, Southport Red and Yellow Globes, and Ohio Yellow Globe. Southport White Globe, Mountain Danvers, Extra Early Yellow, Early Yellow Globe, and Red Wethersfield sometimes appeared in the long-storage group but usually did not hold up as long as those named above. Wilson's (17) results also show variation in keeping quality of the same variety during a 3-year period, but the rating of variety based on the 3-year average agrees well with the above grouping.

Strain differences in the ability of the selected sample to remain in good condition in the storage were not very marked or consistent, except in the case of the Prizetaker and White Portugal varieties. Strain 2 of Prizetaker had a consistently slightly higher percentage of sound bulbs than strain 1 throughout the 1933 cold storage trial at Arlington, Va., and strain 3 had a slight advantage over strain 1 in the 4-month storage trial at 65° to 75° F. at Arlington in 1934 and about 32 percent more sound bulbs than strain 2 at the end of the 90-day storage period at 52° at Davis, Calif., in 1933. Strain 4 of White Portugal had 27 percent more sound bulbs than strain 2 at the end of the 90-day period at Davis in 1933, and strain 3 had 2.5 times as many as strain 2 at the end of 120 days when stored at 65° to 75° at Arlington in 1933. This lack of wide variation in storage quality in the more uniform strains of most of the varieties studied is an indication either that the selection of the sample for storage eliminated possible differences in storage ability, or that the seed producers used the same stock or had attained the same degree of storage quality.

Although strain differences in percentage of sound bulbs at the end of the storage period were not great, there were differences in the amount of rotting, sprouting, rooting, softening, and shriveling, and loss in weight while in the storage, between strains of some of the varieties, as the data in tables 1 to 6 inclusive, 12 to 16 inclusive, 17, and 31 to 33 show. In some cases the greater percentage of sprouts in one strain is counterbalanced by a greater percentage of rots in the other contrasted strain, with the result that there is often no significant difference in percentage of sound bulbs at the conclusion of the experiment. In other cases greater losses due to one factor in the early part of the storage period may be offset by smaller losses during the later part.

No doubt a considerable number of the differences in rating of varieties in different years at the same location and between locations could be explained if more complete records were available on the weather conditions at the time of maturity and curing and the relative stage of maturity at the time unfavorable growth conditions, such as severe thrips damage, hot drying winds, mildew, and pink root damage occurred. Unfortunately these data are not available for all locations.

Experience has shown that only normally matured, well-cured onions should be stored for any appreciable length of time. Normal maturity means that maturity will take place under favorable conditions for the gradual decline of root and leaf activity with a gradual softening of the neck and a transference of the soluble solids of the leaves into the bulb, so that the outer succulent layers of the bulb

nearly close the opening over the leafless inner scales. Any cause of premature death of the leaves causes the neck of the bulb to remain open and permits the entrance of moisture and various rot organisms. Open and thick-neck bulbs soon resume growth (sprout) or rot (1, 4). When decay is not a factor, quicker sprouting is thought to result from the greater accessibility to oxygen of the central growing point in the open or thick-neck bulbs than in the bulbs with well-closed necks (1).

The combined serious damage of the foliage resulting from a severe thrips infestation, excessive temperatures, and drying winds that quickly killed and dried the foliage, resulted in large, open necks and in poor storage quality of the 1933 crop at Arlington, Va. Rains during the curing period further complicated the situation by introducing neck rot; and even though the bulbs were quickly dried under artificial conditions, the loss prior to storage was very high as shown in the data. In irrigated sections cutting off the water before maturity has advanced far enough resulted in large open necks and subsequent poor storage quality. Cutting the roots to aid in the death of the tops has been shown (14) to have a detrimental effect upon storage quality. The practice of rolling down or breaking over the tops to hasten their death likewise has had a detrimental effect in this respect (6, 14).

The poor storage quality of Sweet Spanish and Prizetaker grown in Texas was due to their failure to mature normally. All of the varieties reported herein were grown at Winter Haven, Tex., but only those given in the Texas data made sufficient bulbs of any quality to warrant a storage trial, for reasons given in the text and in an earlier report (11). Sweet Spanish and Prizetaker were enabled to make a few bulbs of poor quality, probably because of resistance to damage by thrips and pink root. These varieties require a long growing season and do not ripen as uniformly or as rapidly as do the domestic storage varieties, with the result that they frequently encounter rainy cool periods in New England and the Northern States and do not ripen properly, or they keep very poorly when matured under such conditions. The importance of dry, hot weather during maturity for properly ripening and curing onions is recognized, but it is only recently that attention has been drawn to its importance in bulb formation and maturity (15). The minimum length of day at which bulb formation will take place (12) is influenced markedly by temperature, and it may also be that the failure of late varieties, such as these, to mature in rainy fall seasons is as much the result of lower temperatures as of the rainfalls. Most of the American-grown Spanish-type onions are produced in irrigated valleys in the Western States where no rain falls near the end of the growing season. Temperatures and length of day are favorable for bulb formation and even though cooler temperatures occur during the latter part of the growing season, the crop is ripened and dried down by gradually withholding and eventually stopping irrigation.

The 1933 Texas data indicate that Bermuda onions which are allowed to mature fully so that the tops become partially dry in the field before pulling do not keep so well as those that are harvested and clipped in the usual manner when only about 60 percent of the plant tops have fallen over. Such earlier harvesting is in accord with the

practices of the most successful growers (7) in a district where rain at harvesttime is unusual. The poor keeping after later harvesting may be due to the fact that soil-inhabiting rot-producing organisms gain entrance through the dying roots or that the additional time in the soil may prevent the bulbs from becoming completely dormant. Chroboczek (3), working in Poland with storage varieties, also found that onions pulled before the tops were yellow and dry kept better than those pulled later.

The effect of rain during maturity on keeping quality is also clearly shown in the 1933 results at Arlington, Va. The general results indicate California Early Red to be in the same class (poor) with Yellow Bermuda and Crystal Wax, yet the percentage of rot that developed between harvest and storage was only a third or a fourth that of the two latter varieties. Rains at the time when harvesting should have been done and slow drying of the foliage and necks after harvest on the Bermuda varieties were ideal for the development of neck and other bulb rots, as has been pointed out (16). In the case of California Early Red, which matured a few days later, the foliage was not rained on after it fell over and the movement to the dry greenhouse apparently checked the spread of decay organisms. In the discussion of the Massachusetts results it is also pointed out that a delay in harvest with intervening rains was also responsible for poor storage quality of ordinarily good storage varieties.

The present results agree with those of other investigators (2, 3, 4, 5, 9, 15, 16, 18) in that bulbs stored at high temperatures lost marketability faster than when stored at low temperatures, as shown by the 1933 results at Amherst and the 1934 results at Arlington. At Arlington, where the high temperature (65° to 75° F.) was rather uniform and higher than at Amherst, 2 months in storage at the high temperature caused about the same amount of loss as 9 months' storage at 40°. During the same time interval at Amherst all of the varieties lost a greater percentage in the shed storage where the temperatures were higher and fluctuated more than they did in the cold storage where the relatively uniform temperature was about 40°.

CONCLUSIONS

Crops of onions of the important American varieties were grown from the same lot of seed at Arlington, Va., Davis and Terminus, Calif., Amherst, Mass., Columbus and McGuffey, Ohio, and Winter Haven, Tex., and stored under different conditions for different lengths of time. As a result of the tests conducted during a 2-year period, the varieties tested may be placed in the following groups with reference to their suitability for storage:

<i>Variety</i>	<i>Suitability for storage</i>
Italian Red.....	Very poor.
California Early Red.....	
Crystal Wax.....	} Poor.
Yellow Bermuda.....	
Early Grano.....	
White Sweet Spanish.....	} Fair.
Prizetaker.....	
Sweet Spanish.....	

<i>Variety</i>	<i>Suitability for storage</i>
Red Wethersfield.....	} Good.
Mountain Danvers.....	
Extra Early Yellow.....	
Early Yellow Globe.....	
Yellow Danvers Flat.....	
Yellow Strasburg.....	
Southport White Globe.....	
Southport Red Globe.....	
Southport Yellow Globe.....	
Ohio Yellow Globe.....	
White Portugal.....	} Very good.
Ebenezer.....	
Yellow Globe Danvers.....	
White Creole.....	
Red Creole.....	
Australian Brown.....	

Although the number of strains of each variety was small and the strains selected for storage were the most uniform in type, there were marked differences in the amount of rotting, sprouting, softening and shriveling, and loss of weight while in storage.

Differences in the rank of the varieties at the different locations could usually be ascribed to such factors as stage of development of the bulb at time of harvest, conditions during and immediately following maturity, length of time between harvest and storage, conditions in the storage, and length of the storage period.

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